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POUR L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT – DANEMARK

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E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
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AOÛT 1937

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A/S L. IHRICH - COPENHAGEN

A Review of the Norwegian Herring Investigations in Recent Years.

By

Sven Runnstrøm,
Bergen.

ALONG the Norwegian coast different herring fisheries occur at different seasons and on different parts of the coast. We have the fishery for small-herring along the main part of the coast, the fat-herring fishery of northern Norway in the summer and autumn, and the large- and spring-herring fishery on the west coast in the winter and spring.

G. O. Sars (1873) was the first scientist to recognize the true relationship between the different "sorts" of herring, namely that the small- and fat-herring represented the immature stages of the full-grown spring-herring. When the method of determining the age and growth from the herring scale was introduced in the Norwegian herring investigations by Johan Hjort and his collaborators at the beginning of this century the opinion of Sars was not only confirmed, but our understanding of the life history of the Norwegian herring was greatly increased.

The important results of the work in the years following the introduction of the new methods appear clearly in the book by Johan Hjort (1914), "The Fluctuations in the Great Fisheries of Northern Europe."

An extensive collection of herring samples for age determination was organized, and continuous observation of the stock has proceeded since 1907. These observations early led to the fundamental discovery of the great fluctuations in the numerical strength of the year-classes, which in those first years of investigation of the Norwegian stock were made especially clear through the appearance of the rich year-class 1904. From the long series of observations Lea (1930) has since been able to calculate the mortality in the Norwegian spawning stock and the relative strength of the stock in different years.

As regards the main features in the life history and migrations of

the Norwegian herring, it was at first assumed that the fry were carried northward along the coast by the current and that the young herring grew up mainly in the northern waters, where they later played a part in the formation of the fat-herring shoals. When the genital organs were beginning to develop, at an age of 4 to 6 years, the herring migrated southwards and appeared in the autumn some distance north of the spawning grounds as large-herring, and in the following spring on the south-west coast as spring-herring. The transition from immature herring to spawning herring should then be direct and of short duration, and should take place in coastal waters.

However, L e a (1929 II) recognized that this assumption did not harmonize well with the observations of age, length, and growth of the two groups. The young herring present along the coast were too young, too small, and too little sexually developed for the recruit spawners to be derived directly from them. There must be an intermediate stage in the life cycle of the Norwegian herring which was not commonly seen, and which gave rise to no coastal fishery. L e a was able to draw up a provisional description of the herring in the intermediate stage before the supposed oceanic group had been subjected to direct examination. In the summer of 1927, herring shoals appeared along the coast off Bergen which showed those very features L e a had expected, and the existence of an intermediate stage was thus confirmed.

The discovery by L e a was of great importance to an understanding of the life history of the Norwegian herring. The young herring leave the coastal waters and migrate seawards at a certain stage. However, this migration does not take place simultaneously for one and the same year-group, but at different ages according to individual development. The young herring on the west coast disappear earlier than those in more northern regions, where they may remain as fat-herring for a varying number of years. It seems as if the so-called "large fat-herring years" occur when the oceanic group of herring is driven to the coast by unknown causes or when the departure from the coast is delayed.

In the oceanic intermediate stage the young herring develop to mature individuals and migrate then as recruit spawners to the spawning places, where they join the group of older spawners. Between the spawning periods the group of spawners seems to make extensive migrations in the Norwegian Sea and in the summer have been encountered as far north as Bear Island and Spitsbergen (I v e r s e n 1935).

As regards racial characters it was supposed that the Norwegian waters had a common race and that the fishery rested on different stages of one and the same herring stock. G. O. S a r s at one time assumed the presence of two herring stocks, a southern one and a northern one, on account of the big fishery for large-herring which existed in northern Norway at that time, but he later gave up his assumption. H e i n c k e (1898) regarded the Norwegian herring as one of the best-defined races and B r o c h (1908), who made a racial

analysis with much more data, pointed out that the herring in Norwegian coastal waters belonged to one and the same race, with the exception of some small local races.

Schnakenbeck (1931) thought that he could detect two morphological types among the Norwegian herring with differing frequency curves for Vert. S. He therefore assumed the existence of two races without being able to distinguish them, however, with regard to place and time of spawning. In a preliminary report in this Journal (1933) I have discussed Schnakenbeck's results. The data on number of vertebrae have since greatly increased, during the years 1932—36, and relate to about 55 thousand individuals, and a final report on the racial investigations will be made in the near future.

However, before considering the main results of the racial investigation it will be of interest to give some information about the present distribution of the large- and spring-herring fishery and of the spawning places along the Norwegian coast.

The large-herring, which represent the mature herring mainly in Stages IV and V, appear in the coastal waters usually in the latter part of December, and the large-herring fishery continues until the end of January before showing a decline. In the beginning of February spawning starts, and the herring with running gonads are now called spring-herring. The spring-herring fishery culminates in February and usually ends in the latter part of March.

In Figure 1 I have given the average catch in the period 1932—1936 in the several well-known fishery districts on the west coast. Each circle indicates 10,000 hl.

The black dots indicate herring caught before the 1st of February, when they are still in the large-herring stage, and the open circles indicate herring caught after that date, when they represent mainly spring-herring. The period of transition from large-herring to spring-herring will, of course, vary to a certain degree in different years and in different districts, and the spring-herring shoals will also often contain less developed individuals, but the figure shows the main features of the distribution of the present large- and spring-herring fishery.

One finds that the fishery occurs along the coast from Lindesnes in the south to about Trondheimsfjord in the north. The fishery is, however, not equally distributed along the coast and one can recognize three distinct regions (I—III) in the centre of which the fishery culminates.

The first region (I) is from south of Bergen to Lindesnes (Rogaland — S. Hordaland) with the most important fishery localities at Skudefjord and Sirahavet. This region is a predominantly spring-herring district with well-known spawning places. The herring usually appear at the end of January a short time before the spawning season and in the first week of the fishery they may still be in the large-herring stage.

The second region (II) is from Bergen to Stat (N. Hordaland — Sogn and Fjordene) with a centre outside Sognesjøen. Since 1929

the fishery here depends almost exclusively on the large-herring and culminates in January, after which time the herring disappear. Before 1929 this region was mainly a spring-herring district, but this fishery was insignificant in comparison with the great catches of large-herring landed in later years.

The third region (III) comprises the coast from north of Stat to Halten (Møre — S. Trøndelag) with the main fishery outside Ålesund. This region was formerly the main large-herring district but lately the large-herring fishery has decreased and the spring-herring fishery increased. In the present year (1937) the large-herring fishery failed totally, though the spring-herring fishery was fairly good. Investigation of the distribution of the newly hatched larvae and direct observation of the distribution of herring roe on the bottom by means of the grab have shown fairly extensive spawning places in this district.

North of these three regions there is no regular fishery for large- and spring-herring, but my investigations (1934, II) into the distribution of newly hatched larvae have shown that spawning occurs also in northern Norway as far north as Vesterålen. Occasionally large- or spring-herring are caught here and this was especially the case in the spring of 1935, when the presence of spawning herring was observed in Andfjord, north of Vesterålen, and along the Helgeland coast at the end of March and beginning of April. A representative sample of this northern spring-herring was collected.

There exist thus at least two different spawning centres, one on the south-west coast between Bergen and Lindesnes, and another north of Stat along the Møre coast. These two centres are separated by a region between Stat and Bergen which at present is a typical large-herring district where no extensive spawning occurs. There is also more or less regular spawning on the coast of Northern Norway.

As already mentioned the large- and spring-herring fisheries have not always had the same distribution as in recent years. The spring-herring fishery on the south-west coast (Region I) has been the most constant and existed in olden times, but it has been interrupted by periods when the herring have been almost entirely absent from the coast. The earlier period of the spring-herring fishery lasted from 1815 till 1872, after which year the herring almost disappeared. This period of scarcity lasted until about 1882, when the herring again began to return to the old spawning places. In the latter part of the former period there was also a fairly important spring-herring fishery on the coast of Sogn and Fjordene and Møre. From that period we have also the first information of a large-herring fishery which occurred in northern Norway in the fjords of Troms, Lofoten, and Helgeland in the years 1863—1874. The presence of this large-herring so very far away from the spring-herring districts caused G. O. Sars to regard the large-herring as belonging to another and more northern herring stock than that of the spring-herring. Shortly after the disappearance of the spring-herring the large-herring fishery ended also.

When the new spring-herring period began in 1882, the fishery was

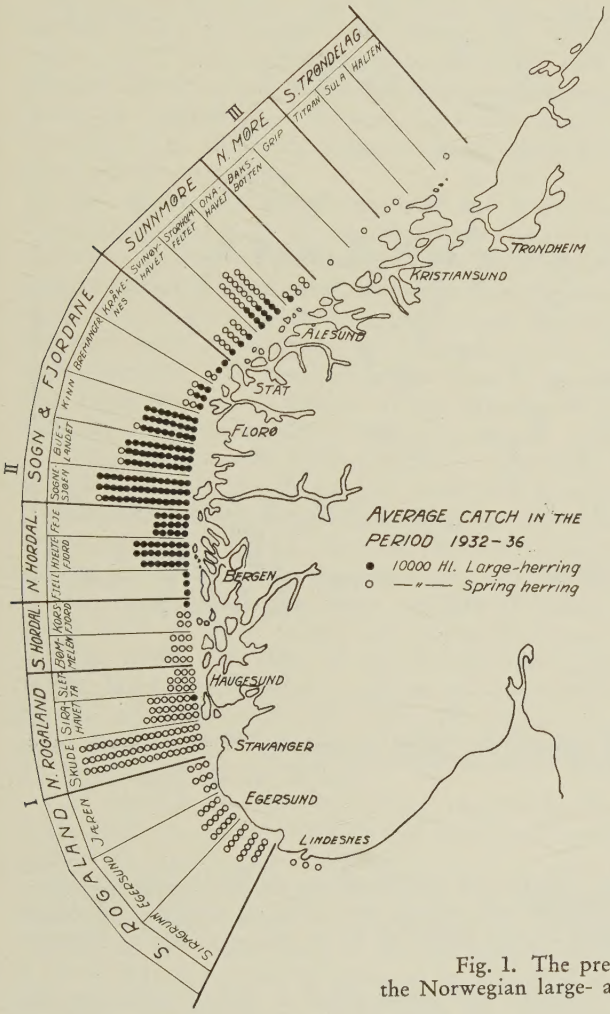

Fig. 1. The present distribution of the Norwegian large- and spring-herring fisheries.

restricted mainly to the south-west coast, and there was only a very unimportant spring-herring fishery in the districts north of Bergen.

Then in the 'nineties great shoals of large-herring suddenly appeared off the coast of Møre, and the fishermen learnt to catch the herring with drift-nets in the open sea. The large-herring fishery at that time began as early as the autumn, and the herring disappeared in January before the spawning time and were supposed to migrate to the spawning grounds on the south-west coast. The large-herring fishery was at first concentrated in the southern part of Møre but moved later on northwards to the northern part of Møre and Trøndelag, and then back again to the southern coast of Møre. Since 1929 the most

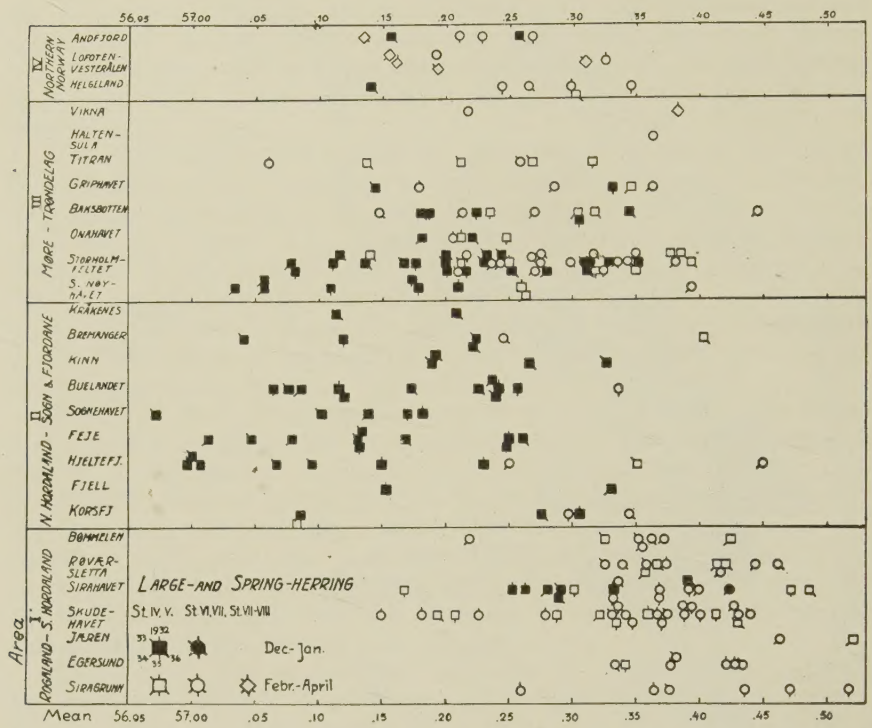

Fig. 2. The mean of each sample of vertebral counts of Norwegian large- and spring-herring in relation to area.

important large-herring fishery has taken place south of Stat in Sogn and Fjordene and N. Hordaland, where formerly no extensive fishery took place, while the Møre coast seems to have changed into a spring-herring district.

Thus fairly great changes have taken place in the distribution of the fisheries and especially of the large-herring fishery, and this fact seems to indicate changes in the movement to the coast of the spawning shoals.

The question is, then, Have we a common spawning stock which in the large-herring stage appears at the present time on the coast of Bergen — Stat and Møre and then mainly migrates southwards to spawn on the grounds off the coast of Bergen — Lindesnes, while a smaller part remains on the spawning grounds north of Stat? Or are there two racially different spawning communities, one on the south-west coast and one on the Møre coast, and what relationship then exists between the large-herring in the intermediate region and those in the two spawning communities?

Figure 2 demonstrates graphically the mean values of Vert. S. in

relation to the area. The black symbols represent samples of large-herring from December and January in Stages IV and V, and the open symbols spring-herring from February and March. As the spring-herring shoals are not always homogeneous as regards the stage of maturity, Stages IV—V have been separated from Stages VI—VII. Samples from different years are distinguished by the situation of the cross on the symbols.

As regards the mean values of the spring-herring samples there is no grouping for stage of maturity, and the average number of vertebrae decreases from south to north. Looking at the distribution of the mean values of the large-herring, one finds that the samples from the southern spawning district (I) do not differ from the spring-herring samples in the same area, while in the more northern area, N. Hordaland — Sogn and Fjordene (II), there is a pronounced movement in the means of the large-herring to lower values. Farther north the large-herring samples are grouped about somewhat higher mean values.

There seems to be great variation in the mean values of the different samples of mature herring, but there is a pronounced gradation in the distribution of the means according to the situation of the different areas, which indicates that no extensive intermingling takes place among the different groups of mature herring along the coast.

In the vertical column to the left of Table I the mean values are given for Vert. S. of large- and spring-herring.

The whole collection of data from 1932—1936 is divided according to the three main fishery regions (I—III) and a fourth region comprising northern Norway, where the fishery is only occasional. The right-hand part of the table gives the differences of the means measured by their standard deviations.

As regards the spring-herring one finds decreasing mean values from south to north, with 57·353 vertebrae on the south-west coast (I) and 57·273 in northern Norway.

Comparing the mean values of the spring-herring from the two main spawning centres S. Hordaland — Rogaland (I) and Møre — Trøndelag (III) one finds a real difference between the means, which is more than six times as great as its standard deviation. The spring-herring from region II, where only an unimportant spawning occurs, has a mean value which lies between the means of the herring from the two neighbouring main spawning districts. The spring-herring from northern Norway shows a fairly close agreement with the herring spawning on the Møre — Trøndelag coast.

As regards large-herring the fish from the main large-herring district, N. Hordaland — Sogn and Fjordene (II), show a very low average number of vertebrae, while the large-herring from Møre — Trøndelag have a somewhat higher mean value. Measured by their standard deviations the differences between the means of large-herring from region II and those of the large-herring from regions I and III are respectively 6·5 and 3·3. The difference between the means of large-herring from regions I and III is 4·7. There is thus a very small probability that these differences would disappear if new observations

were added. Between the large-herring in northern Norway and those on the Møre coast no great difference seems to exist.

It is also apparent that the large-herring from the three more northerly regions (II—IV) have smaller mean values than the spring-herring from any of the four regions, while the large-herring from S. Hordaland — Rogaland (I) has a value which approximates to the value for the spawning herring in the same district. On comparing the large-herring from N. Hordaland — Sogn and Fjordene with the spring-herring from the four regions along the coast (Table I), one finds that the differences are at least 5 times their standard deviations. The greatest difference occurs between this large-herring group and the spring-herring from the main spawning district on the south-west coast (Region I), where the difference measured by its standard deviation is 19·5. According to Table I there is also a real difference between the mean values for the large-herring from the Møre — Trøndelag coast and those for the spring-herring groups from the four coastal districts I — IV.

It thus seems that the large-herring which appear in December and January mainly on the coast of N. Hordaland — Sogn and Fjordene and Møre — Trøndelag are not identical with the spring-herring spawning in February and March along the coast. But also the spring-

Table I. Vert. S. of Large- and Spring-Herring.

$$\frac{M_1 - M_2}{\sqrt{\mu_1^2 + \mu_2^2}}$$

					Large-Herring				Spring-Herring			
N	M ±μ				Northern Norway	Møre-Trøndel.	S. & Fj. N. Hord.	S. H.-Rog.	Northern Norway	Møre-Trøndel.	S. & Fj. N. Hord.	S. H.-Rog. (– V. Agd.)
370	57·186 ±0·035		IV	Northern Norway	—			3·0	2·2	2·6	3·1	4·6
5261	57.194 ±0.009	Large-Herring	III	Møre-Trøndel.		—	3·3	4·7	3·8	6·6	4·4	14·5
7780	57·158 ±0·007		II	S. & Fj.-N. Hord.		3·3	—	6·5	5·8	11·1	5·6	19·5
951	57·308 ±0·022		I	S. H.-Rog.	3·0	4·7	6·5	—				2·0
1243	57·273 ±0.019		IV	Northern Norway					—		1·5	4·0
5544	57·280 ±0.009	Spring-Herring	III	Møre-Trøndel.						—	1·5	6·6
592	57·326 ±0·029		II	S. & Fj.-N. Hord.					1·5	1·5	—	
10403	57·353 ±0·007		I	S. H.-Rog.					4·0	6·6		—

herring stock is not uniform, and there is a real difference in the average number of vertebrae between the herring spawning at the two main spawning centres, one on the south-west coast and the other on the Møre — Trøndelag coast. On the other hand the data do not show a significant difference between the herring spawning in northern Norway and those spawning on the Møre — Trøndelag coast.

The question is, then, where the large-herring spawn after they have left the large-herring districts at the end of January. The spawning grounds are probably situated outside the coastal fishing localities, and it is then reasonable to expect the spawning places to lie on the other side of the Norwegian Deep on the edge of the northern North Sea plateau, for instance, on the Viking bank, where herring roe has been observed by Scottish investigators. B j e r k a n (1917) has also assumed the occurrence of spring-herring spawning on "Revkanten". The low number of vertebrae of the large-herring agrees also fairly well with that of the spring-spawning herring from Viking bank.

The opinion formerly held, namely, that we have a uniform Norwegian spring-herring stock which at first approaches the more northern districts as large-herring and then migrates southwards to the spawning grounds on the south-west coast in order to spawn, cannot be maintained. Probably we have to do with different spawning communities in the Norwegian waters with their main spawning places on the south-west coast, the north-eastern edge of the North Sea bank, the Møre coast, and northern Norway. These spawning communities show different morphological characters as regards the number of vertebrae. The question of the difference in number of vertebrae being constant and inheritable or only being caused by different external conditions on the spawning grounds cannot be settled with certainty, but this problem has no bearing on the question discussed here. In my opinion, however, it is reasonable to assume that the number of vertebrae is to a certain degree influenced by external factors, such as, for instance, the temperature. It may be supposed that the rising temperature along the west coast from south to north, due to the increasing influence of Atlantic water, has the effect of diminishing the number of vertebrae. The lowest number of vertebrae is then to be expected in the large-herring which are supposed to spawn in the open sea under still more Atlantic conditions.

What is now the relationship between the young herring growing up along the coast and the different spawning communities? After larvae have been hatched in spring one finds, in the course of the summer, herring fry distributed along the whole coast from the west coast to the remotest parts of northern Norway.

As Table II shows, there is a gradation in the average number of vertebrae in the fry along the coast, which indicates that no extensive intermingling of the fry hatched on the different spawning grounds takes place. In the same manner as for the spring-herring one finds decreasing mean values from south to north. It must, however, be supposed that a certain drift of the fry northwards from the spawning places occurs in the course of the first year, and the young herring

Table II. Vert. S. of the 0-Group.

Locality	N	M
IV. Northern Norway	5660	57·187 ±0·009
III. Møre—Trøndelag	2981	57·198 ±0·012
II. N. Hordaland, Sogn and Fjordene ...	1339	57·352 ±0·019
I. S. Hordaland—Rogaland	1250	57·524 ±0·021

which grow up on the Murman coast must, according to Awerinzew (1935), originate from Norwegian spawning grounds.

The vertebral counts give, however, no clear information as to what extent the young herring which grow up in the different coastal regions take part in the formation of the different spawning communities.

One must therefore look for other characters which may give some additional information about the migrations of the young herring and about the formation of the spawning shoals.

Hjort and Lea (1911) conceived the idea that one and the same group of mature herring may be composed of several growth-types, and that extraordinary growth phenomena may be utilized for the special investigation of the composition of a single herring-group and its migration. They found that a great number of individuals of year-class 1904 among the fat-herring from northern Norway had in their third year an abnormally small increment of growth, which was smaller than the increment in the fourth year. Hjort and Lea could then later follow the immigration of these "marked" herring into the group of spawners on the south-west coast, and concluded from these observations that the northern fat-herring joined the spring-herring shoals in southern Norway.

Ottestad (1934) has later shown that this growth-type, which he calls the C-type ($t_3 < t_4$), is common in all year-classes of the Norwegian herring. He also introduces a B-type with a smaller growth-increment in the second year than in the third year ($t_2 < t_3$), while the A-type represents herring with decreasing growth-increments with increasing age ($t_1 > t_2 > t_3$ etc.). These growth-types are illustrated in Fig. 5. Ottestad finds, however, that the A-type of the spawning herring on the south-west coast has a growth-rate greater than that of the corresponding growth-type of the northern fat-herring, and from this fact he concludes that the A-type of the fat-herring in northern Norway is not identical with the A-type of the southern spring-herring. The same is demonstrated as regards the C-type of the two herring groups (Fig. 3). However, the first year's growth-increments of the A-type of the northern fat-herring show

the same values as the corresponding increments of the C-type of the southern spring-herring. From this finding Ottestad concludes that the proof given by Hjort and Lea of a migration of the "marked" northern fat-herring to the spawning grounds on the south-west coast does not hold good. He considers it doubtful whether the northern fat-herring join the southern spring-herring shoals at all and, at any rate, if any migration does take place, it is only the A-type of the fat-herring which undertakes such a migration.

As, in the opinion of Ottestad, only a portion of the northern fat-herring stock, viz, the individuals of the A-type, later joins the southern spring-herring shoals, he concludes that there exist two Norwegian herring stocks, a southern and a northern one. The northern herring stock is supposed to spawn in northern Norway, where the writer had shown the occurrence of newly hatched larvae.

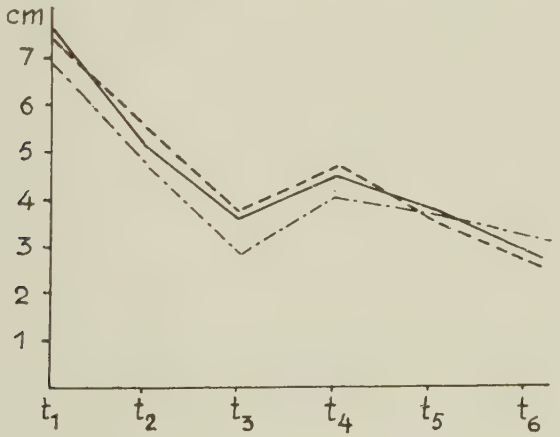

Fig. 3. Graphic representation of the mean yearly increments in length of the C-type of the year-class 1904, ———— spring-herring, — — — — large-herring, —·—·—·— fat-herring. From Ottestad 1934.

There exists, however, a possibility, which Ottestad does not take into consideration, that the three growth-types A, B, and C of southern spring-herring are not homogeneous, but have components representing herring of different origin. The C-type of the spring-herring may, for instance, represent a medium type of herring of northern origin with a small growth-rate and herring of southern origin with a very high growth-rate.

It was therefore desirable to find a method which would permit a further division into growth-types according to the different life histories of the herring.

Lea (1929 I) found that the appearance of the winter rings on the scale varied, and he considered that the peculiarities that may be observed on the scales of a herring form a picture of the dependency of the herring upon, and its reaction to, the environment in which

it has lived during the course of its life. The rings differ because the environment differed in the periods when they were formed.

As regards the Norwegian herring L e a observed that the rings are as a rule sharper in the young herring caught in northern Norway than in the herring taken on the southern part of the west coast. He also found differences between the rings in one and the same scale

Fig. 4. Scale of a 7-year-old spring-herring from the Norwegian west coast with different appearance of the winter rings. From L e a 1927.

which are best illustrated by a photographic reproduction (Fig. 4) given by L e a (1927). The scale is taken from a seven-year-old spring-herring caught on the spawning grounds on the west coast in spring. The three inner rings are sharp and have the same appearance as the rings on the scale of young herring from northern Norway, but the fourth ring has a quite dissimilar appearance and recalls in some degree rings found on scales from Shetland herring. The two outer rings have the same stamp as commonly found in old Norwegian herring.

L e a interprets the life history of this herring in the following manner. The herring has lived the first three years in northern coastal waters, but has then in the next spring emigrated into the open sea where it has lived during the fourth winter and fifth summer. In this oceanic stage the herring has come to maturity and has then at an age of five years joined the spawning shoals.

L e a does not give any proof of the correctness of his interpretation of the differing appearance of the winter rings, but if it is correct, one has here a good method by which to trace many important features in the life history of each single herring.

While working on scale analysis I soon realized that an analysis of the character of the winter rings would be of great value for the study of the life history of the Norwegian herring, and in a newly published paper (1936) I made a systematic study of a large collection of data in order to verify L e a's view.

Table III.

Age	Ring type	Small- and Fat-Herring from coastal waters			Oceanic intermediate stage from the west coast
		West coast	Møre-Trøndelag	Northern Norway	
		%	%	%	%
1½	S	92·1	48·8	7·7	85·9
	N	7·9	51·2	92·3	14·1
2½	S	81·0	35·9	10·9	78·7
	N	19·0	64·1	89·1	21·3
3½	S	69·2	12·9	3·2	50·7
	N	30·8	87·1	96·8	49·3
4½	S		1·3	1·8	13·4
	N		98·7	98·2	86·6
5½	S			—	—
	N			100·0	100·0
6½	S				—
	N				100·0

While studying data relating to young herring in the second year of life from different localities along the coast, I found that the two ring types, which may be called "southern" (S) and "northern" (N), are as a rule very well distinguished. As may be seen in Table III, about 92 % of the young herring from the west coast (south of Stat) have a "southern" ring, while 92 % of the herring in northern Norway have a "northern" ring. In the intermediate area Møre — Trøndelag one finds the two types about equally mixed.

It is thus apparent that the "northern" type of winter ring is formed mainly in northern coastal waters, and the "southern" type on the west coast, while the Møre — Trøndelag coast is a transition area.

One finds also from the table that, with increasing age, there is a relative increase in the number of herring of the northern type, which is most pronounced on the west coast and at Møre—Trøndelag. This may be caused by the earlier emigration of herring of the "southern" type from the coast or by an immigration of young herring of northern origin.

In the column farthest to the right of Table III one finds the composition of a herring shoal in the oceanic intermediate stage which occasionally visits the west coast. The herring are then reaching sexual maturity. This shoal is composed of six age-groups representing ages from 1½ to 6½ years in contrast to the young herring commonly met with in the coastal waters of southern Norway where they are mostly represented by fairly young age-groups.

In the two youngest age-groups the "southern" type is predominant, while the 4½ to 6½-year-old herring, age-groups which in the coastal fat-herring shoals are only met with in northern Norway, are mainly of the "northern" type. The 3½-year-old herring are represented by an equal number of the two ring-types. One gets the impression that the herring in the oceanic intermediate stage represent an intermingling of two contingents, one consisting mainly of younger fish, emigrants from the southern coastal water, and another contingent of older fish which have migrated southwards from more northerly coastal waters. The common feature in the herring of the two contingents is that the development of the sexual organs has begun.

Some of the herring in the oceanic intermediate stage had all the winter rings of that type which was supposed to be formed in the coastal waters, while others had one or two rings of the same type as the fourth ring on the scale in Fig. 4, which were supposed to be formed in the open sea. This means that some of the fish had left the coast in the preceeding summer, while others had lived one or two winters in more oceanic conditions. For a more detailed analysis of the scale types I must refer to Tables 2 and 3 in my paper, 1936, II. The herring caught in the autumn were, however, not so far advanced in sexual development that they could be expected to spawn next spring. It must therefore be supposed that this group of herring would remain another year in the oceanic stage before appearing as recruit spawners on the spawning grounds. All the herring must acquire a new winter ring in addition to those already present before they spawn, and as the herring in this stage live in the open sea this ring must be of the "oceanic" type. When the herring appear on the coast as recruit spawners they must thus be 1½ years older and at least the last visible ring must be of the "oceanic" type.

An analysis of a shoal of recruit spawners from the west coast actually showed the features expected. As may be seen on the left-hand side of Table IV, the shoal was composed of the same number of age-groups as the oceanic group, but was from 3 to 8 years of age. As regards the proportion of northern to southern type, each age-group is similar to the corresponding 1½ years younger age-groups of the oceanic group.

Table IV.

Recruit Spawners from the west coast			Older Spawners				
Age	Ring type	%	Age at 1st spawning	Ring type	West coast %	Møre—Trøndelag %	Northern Norway %
3	S	100·0	3	S	100·0	100·0	—
	N	—		N	—	—	—
4	S	80·8	4	S	89·5	88·5	75·9
	N	19·2		N	10·5	11·6	24·1
5	S	43·2	5	S	56·7	40·7	30·9
	N	56·8		N	43·3	59·3	69·1
6	S	4·9	6	S	9·2	1·0	3·9
	N	95·1		N	90·8	99·0	96·1
7	S	—	7	S	—	—	—
	N	100·0		N	100·0	100·0	100·0
8	S	—	8	S	—	—	—
	N	100·0		N	100·0	100·0	100·0
9	—	—	9	S	—	—	—
				N	—	—	100·0
			Total	S	48·6	32·2	19·3
				N	51·4	67·8	80·7

As shown in Table 3 in the original work (1936, II) the last visible winter ring in all the herring was of the "oceanic" type, which is proof of the correctness of the assumption that this ring type is formed in the open sea.

The new winter ring just being formed at the edge of the scales of the recruit spawners represents the first spawning ring. If this appears different from the "oceanic" rings, one should find one or more such spawning rings outside the "oceanic" ring in the group of older spawners which have spawned one or more times before. The group of older spawners usually appears earlier in the season and separately from the recruit spawners. As shown in Fig. 4, the outer rings on the scales of older spawners have, in fact, a different appearance from that of the "oceanic" ring. If these rings indicate spawning rings, we have a method by which to divide the older spawners into different spawning groups according to the age at first spawning.

If the recognition of the spawning rings is correct, one must expect to find the composition of the group of older spawners in regard to spawning groups similar to that of the recruit spawners in regard to age-groups. This is actually the case, as Table IV shows. One finds that the older spawners from the west coast comprise 6 spawning groups, representing herring which spawned for the first time at an age from 3 to 8 years. The different spawning groups show also the same composition as regards herring of "northern" and "southern" type

as the corresponding age-groups of the recruit spawners. The herring spawning for the first time at an age of 3 and 4 years are mainly of southern origin, while those spawning at an age of 6 to 8 years are mainly of northern origin. The spawning group 5 shows herring of the two types in about equal numbers.

The analysis of the character of the winter rings thus seems to prove that the spring-herring shoals on the west coast consist of two contingents representing herring of different origin, which in the oceanic stage join into a spawning shoal. The one contingent grows up in more northern waters and reaches sexual maturity at a later age than that of the herring of the other contingent, which grow up in the coastal water of southern Norway.

As is to be seen in Table IV, the two contingents are represented by an equal number of herring among the spring-herring on the west coast, while the more northern spawning communities show an increasing number of herring of northern origin. The spring-herring in northern Norway are about 80 % "northern" type. However, one must not assume that the herring of the "northern" type which join the southern spring-herring shoals are identical with the herring of this type which appear on the northern spawning grounds. The young herring with "northern" winter rings cover a wide area, from Trøndelag to the northernmost parts of Norway. Also the young herring on the Murman coast, which according to A w e r i n z e w (1935) must spawn in Norwegian waters, are mainly of the "northern" type. It is then reasonable to assume that the spring-herring on the northern spawning grounds are mainly recruited from the young herring stock on the Murman coast, which assumption agrees with A w e r i n z e w's view, while the young herring growing up in the fat-herring districts of northern Norway migrate to more southern spawning grounds. The "northern" elements show also a higher average number of vertebrae in the spring-herring shoals on the west coast than they do in the shoals on the more northern spawning grounds.

It is apparent that the method of reading the life history of herring on the scale allows an analysis to be made of the growth history of the herring according to the origin of the individual. The opinion that the growth-types A, B, and C of the southern spring-herring are composed of fish of different origin and with different growth-rates can now be tested.

In the upper section of Figure 5 one finds the growth-curves for the A, B, and C-types of the year-class 1904 present as fat-herring in northern Norway in 1909. In the middle section, growth-curves are given for the different components of the C-type of the same year-class as the spring-herring from southern Norway in the year 1914, and separated according to the life history of the herring. The diagrams show that the C-type of the spring-herring is not homogeneous, but that it represents a mixture of many biological groups, each with a different growth history. The herring of southern origin (curve I) have grown faster early in life than the herring of northern origin (curves II—V), but there is also a gradation in the growth-rate among the

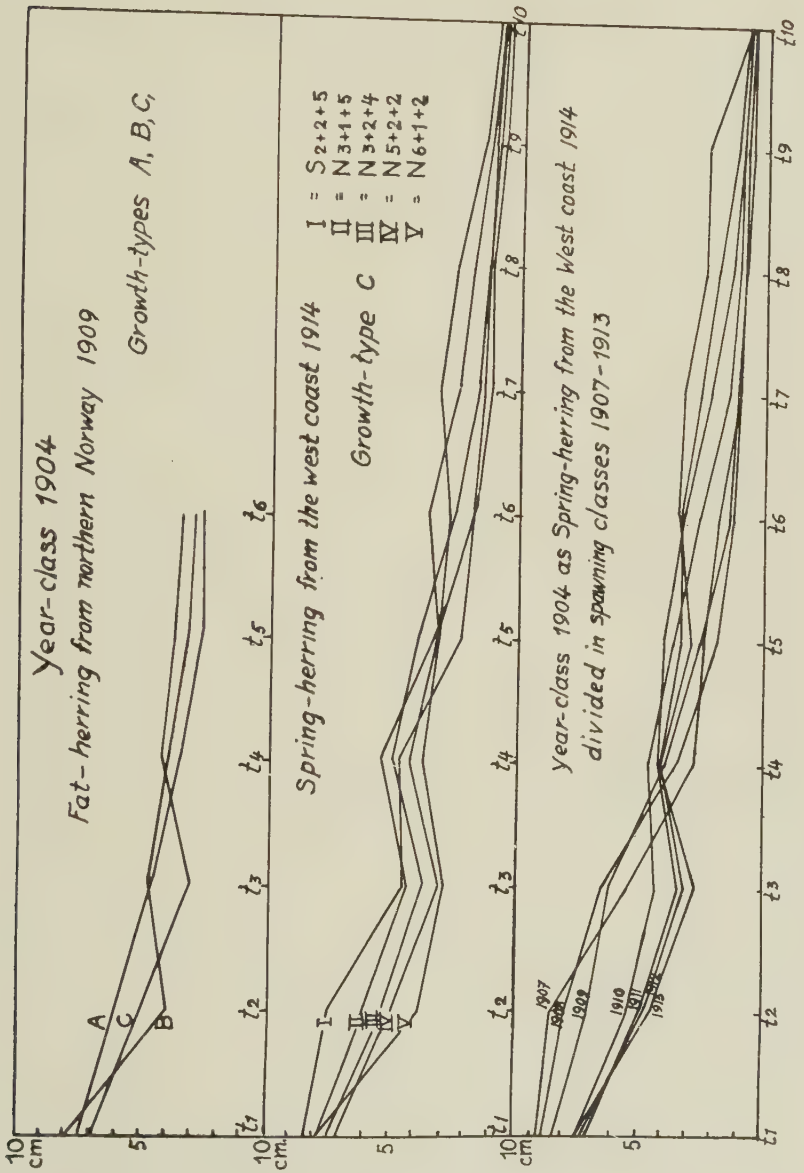

Fig. 5. Mean yearly increments in length of the year-class 1904,
1. A, B, and C-types of fat-herring from northern Norway.
2. C-type of spring-herring divided into different components according to origin and life history of the herring.
3. Spring-herring divided in spawning classes according to the year of first spawning.

latter. The herring which emigrated from the northern coastal waters after the third winter (curves II and III) have grown faster than the herring which emigrated after the fifth (IV) and sixth (V) winters. One finds, further, that the growth-curve IV of the spring-herring is nearly identical with the curve for the C-type of the fat-herring from northern Norway in 1909. The growth-curve IV represents herring of the type N 5+2+2, which emigrated from northern Norway in 1909, lived two winters in the ocean, and then appeared on the spawning grounds on the west coast in spring 1912. In the same manner one can re-encounter the A and B-types of the northern fat-herring among the components of the corresponding growth-types of the spring-herring in southern Norway.

O t t e s t a d's opinion that the B and C-types of the northern fat-herring do not migrate to the southern spawning shoals is thus not correct, and the young herring growing up in northern Norway seem to play a greater part in the formation of the southern spawning stock than he supposed.

The study of the composition of the spring-herring in regard to spawning groups by the method of estimating the age at first spawning gives valuable information about the rate of immigration of a year-class into the spawning stock. Combined with the knowledge of the rate of mortality this information has a practical consequence in the prediction of the composition of the spawning stock as regards age and length.

There seems to be a correlation between the onset of sexual maturity and the growth in the first years of life, as is demonstrated in the lower section of Figure 5. One finds here the growth-curves for the different groups of the year-class 1904, which spawned for the first time in the years 1907—1913. By 1914 all the young herring of the year-class had immigrated into the spawning stock, but the different spawning groups could be separated according to the number of spawning rings.

The growth-curves show that the herring which reached maturity in the year 1907 had greater growth-increments in the first two years of life than the herring maturing in 1908, and the later ones had greater growth-increments than the individuals spawning for the first time in 1909, and so on. The fast-growing groups are mainly of southern origin and the slow-growing ones of northern origin.

It is apparent that the successive immigration of spawning groups with different growth-rates will cause a decrease in the values for the growth-increments t_1 and t_2 in the group of spawning herring, and this gives a biological explanation of the phenomenon of apparent change in growth-rate observed in different species of fish.

One observes also that the early-spawning herring have smaller growth-increments in the later years of life than the later spawning herring. This is probably due to the retarding effect of sexual development on the growth of the fish. The fish with a small initial growth thus tend to add relatively larger annual increments in subsequent years than those with a large initial growth. Through this "compen-

satory" growth the herring of the different spawning groups reached nearly the same average length in 1914.

Combined studies of racial characters and such characters as can be read on the scale have thus given a deeper insight into the composition and recruitment of the Norwegian spawning stock. One must suppose that the Norwegian herring are not so uniform as was formerly assumed and that there exist different spawning communities in Norwegian waters which do not mix to any great degree. Some of these communities spawn on the coastal grounds while others spawn on more offshore grounds, visiting the coastal waters in the large-herring stage only.

As the large-herring do not visit the coastal waters to spawn, one must expect fluctuations in the migration to the coast, which are reflected in the variations of the large-herring fishery. It is probable that the large-herring which appeared in the coastal waters and fjords of northern Norway for a short period in the latter part of the last century really spawned on the more offshore banks of this region, as assumed by S a r s. We know now from the distribution of the newly hatched larvae that spawning still occurs on these banks, but the herring appear less frequently in the inner waters, as, for instance, was the case in the year 1935.

In recent years we have experienced a sudden appearance of enormous quantities of large-herring in the coastal region between Bergen and Stat. This large-herring group does not seem to be identical with the herring in the former main large-herring district on the Møre coast, but represents a new contribution which has enriched the large-herring fishery very much.

Regular observation of the quantity and distribution of the herring roe on the spawning grounds has also shown that variations occur in the migration of the spring-herring to the spawning grounds, causing fluctuations in the spring-herring fishery which cannot be explained merely by fluctuations in the strength of the stock. In certain years the herring spawn mainly in deeper water and on more offshore grounds than in other years, and then the fishery bears only on a part of the spawning stock. The most extreme shifting of spawning places seawards seems to have taken place in the 'seventies of the last century when the spring-herring fishery on the south-west coast was a total failure for a series of years. Herring shoals were, however, observed at sea and herring roe was found in deep water. The abundance of herring fry in coastal waters indicated also that no considerable decrease in the spawning stock had taken place.

In the past season much information has been gained concerning the localization of herring shoals by means of the echo sounder. The spawning shoals in the southern spring-herring district could be mapped and their movements followed throughout the season. It was demonstrated that the fishery fell mainly on the shoals spawning close to the coast, while great herring shoals which remained for weeks on more offshore grounds were not exploited by the fishermen. The presence of fish in great quantities was also registered in the western part of the

Norwegian Deep, close to the edge of the North Sea bank, but this herring never entered the coastal waters of the spring-herring district. Big shoals were also observed at sea outside the large-herring district.

It is probable that the changes in the appearance of the large-herring on the coast and the fluctuations in the immigration of the spring-herring to the coastal spawning grounds are due to changes in the hydrographical conditions in the sea. Since 1935 the Directorate of Fisheries has therefore organized regular hydrographical observations in the northern North Sea in spring and autumn in order to obtain material for a better understanding of the variations in the herring's spawning migrations to the Norwegian coast.

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Phosphate Production by Planktonic Animals.

By

A. C. Gardiner.

SOME preliminary experiments carried out in fresh water suggested that the phosphate content of a natural water may be rapidly increased through the agency of living planktonic crustacea. It also appeared that Cladocera and Copepoda, freshly killed and placed in a jar of water, will similarly raise the phosphate content. The difficulty of preventing *Daphnia longispina* from becoming entangled in the surface film, added to that of making sure that none of the small *Cyclops vernalis,* var. *americanus* used had died during the test period rendered these preliminary experiments of doubtful value. It was decided, accordingly, to repeat the work with marine animals. By the use of a net having 40 threads to the inch it was possible to select only the larger members of the plankton.

The experiments to be described were carried out onboard the "George Bligh", research vessel of the Ministry of Agriculture and Fisheries, in August 1936, and I am greatly indebted to Mr. F. M. Davis, of the Lowestoft Laboratory, for the facilities afforded me. My thanks are also due to Mr. Michael Graham (1) for the use of his photometer, by means of which the concentrations of phosphate were measured on board. To Mr. R. S. Wimpenny I am indebted for the determination of the *Sagitta* present in the material.

The method adopted was to transfer small quantities of plankton immediately after capture to jars containing 200 m.l. of sea water, filtered through silk having 200 threads to one inch. At the end of the test period the animals were strained off through coarser bolting silk and the test water filtered once more through the fine silk to remove faecal pellets. Samples were then drawn for phosphate determination both from the test jars and from similar jars serving as controls. The phosphate content was measured colorimetrically by the Atkins-Denigès method, with Kalle's modification (2). No attempt was made to introduce exactly the same number of animals into each jar. Although it is possible that a few individuals died, careful inspection from time to time showed that the numbers of such were very small.

In the first series of experiments a typical North Sea plankton,

taken in a vertical haul by day, and comprising *Calanus finmarchicus, Temora longicornis, Pseudocalanus elongatus,* and *Sagitta spp.*, was used. The following increases in phosphate during a test period of 3 hours were found.

Table 1.

Series 1.

Temperature 15°C. Experiment No.	Phosphate content m.g. P_2O_5 per cubic metre.	Total number of animals*) per 200m.l. of sea water
A. (Control)	6	0
B. (Control)	9	0
C.	28	184
D.	32	202
E.	27	169
F.	28	227
G.	28	228
H.	36·5	373
J.	44	421

In a second series the plankton was caught in a surface horizontal tow by night. The common animals were Megalopa and Zooea larvae, *Anomalocera patersoni* and *Calanus finmarchicus.* The following increases in phosphate content were found during a test period of 3 hours.

Table 2.

Series 2.

Temperature 15°C. Experiment No.	Phosphate content m.g. P_2O_5 per cubic metre	Total number of animals*) per 200m.l. of sea water.
K. (Control)	9	0
L.	55	123
M.	50	89
N.	60	121

*) The numbers of individual species are shown in Table 3.

In a third experiment a single specimen of *Cyanea capillata,* measuring 6·0 cm. across the disk, was allowed to swim in a jar containing 2,000 m.l. of sea water for 3 hours. The jellyfish was subsequently found to be harbouring 6 specimens of *Hyperia galba* under the disk. The phosphate content was raised from 6 to 25 m.g. P_2O_5 per cubic metre.

In view of the fact that there were considerable differences in the composition of the plankton used in both series of experiments (see Table 3), no useful purpose would be served by computing the unit production. It was hoped to be able to secure sufficient mysids or euphausians to permit a constant number of individuals of one species to be used, but in the area visited neither was taken in large enough quantity to make this possible.

Concentrations of planktonic animals of the order of 1,000 per

litre are, of course, greatly in excess of those normally found in the North Sea (R. E. Savage, private communication), or in the Plymouth area (Harvey (3)). None the less there must be a constant replenishment of the phosphate content of natural waters through the agency of living animals. Moreover, since considerable augmentation was found to have been effected in the space of three hours, it would seem likely that the surface waters will be enriched during those times when the zooplankton migrates to, and masses in, these layers.

Table 3.

Numbers of individual species in each of the test jars.

Series 1.	Experiment						
Species	C.	D.	E.	F.	G.	H.	J.
Calanus finmarchicus	38	35	29	25	42	47	57
Temora longicornis	73	84	83	118	96	205	236
Pseudocalanus elongatus ...	19	14	12	24	25	27	34
Other Copepoda	12	8	8	11	13	35	26
Evadne Nordmanni	5	7	2	1	3	12	10
Sagitta spp.†)	34	49	29	33	39	44	51
Aglantha digitalis	1	3	6	15	10	2	6
Other species	2	2	0	0	0	1	1
Total	184	202	169	227	228	373	421

Series 2.	Experiment		
Species	L.	M.	N.
Megalopa larvae	58	24	71
Zooea larvae	9	16	25
Anomalocera patersoni	2	21	1
Calanus finmarchicus	7	7	9
Temora longicornis	4	2	3
Pseudocalanus elongatus	3	0	1
Other Copepoda	8	5	4
Evadne Nordmanni	2	4	4
Sagitta setosa	19	4	0
Aglantha digitalis	11	6	3
Total	123	89	121

†) Bulk of the *Sagitta* were *S. setosa;* a few *S. elegans* only were present in each collection.

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On the Relation between the Quantities of Phytoplankton and Zooplankton in the Sea.

By

E. Steemann Nielsen.

PHYTOPLANKTON is food for zooplankton; the quantity of zooplankton might therefore be expected to be large where the production of phytoplankton is good, and in general this view is confirmed by observation. In the Atlantic, south of Iceland, where production of phytoplankton is very great at certain seasons, large quantities of zooplankton are found in summer, whereas in the eastern Mediterranean, where the production of phytoplankton is small, zooplankton is scarce.

Often, however, observation suggests that the quantities are inversely related: the zooplankton in certain rich phytoplankton areas is poor and *vice versa.*

Hardy (Hardy and Gunther, 1935) gives an extensive list of literature dealing with this problem, and has discussed the question of relationship very thoroughly on the basis of the plankton records of the "Discovery" expeditions in the South Georgian waters.

Two main theories have been put forward to explain the inverse ratio of the quantities. One theory, which is upheld by Harvey (1934), maintains that zooplankton in large quantities devours so much phytoplankton that this is kept at a minimum. Undoubtedly this is the cause of temporary paucity in areas where the conditions for the production of phytoplankton are poor at certain seasons. This is the case during summer months in Plymouth waters, where Harvey made his observations, and similar conditions have been demonstrated on the north coast of Iceland (Steemann Nielsen, 1935 a).

In areas with optimum conditions for phytoplankton production the attacks by plankton animals do not exert much influence on the quantity of phytoplankton; thus, in the western Irminger Sea there are large quantities of both zoo- and phyto-plankton throughout the summer.

This theory, however, does not explain scarcity of zooplankton in rich phytoplankton areas. For this purpose there is the theory of "animal exclusion", an idea strongly supported by Hardy, who has connected the phenomenon with the vertical movement of the zooplankton. Briefly, his theory is this: Certain species of herbivorous zooplankton move to the upper and phytoplankton-carrying water layers during part of the day only, and the duration of their stay is inversely related to the concentration of phytoplankton. The so-called "animal exclusion" is primarily vertical, but the fact of currents in the upper layers frequently being different from those in deeper ones, may, according to Hardy, cause "animal exclusion" horizontally as well. The chance of plankton animals being carried away is specially great in waters rich in phytoplankton, due to the short time spent on feeding, after which they descend to currents that may run in another direction or at a different speed from that of the upper current.

Certainly it is not possible to disregard Hardy's theory, which in some cases may explain the smallness of the quantity of zooplankton in areas of heavy phytoplankton production. Experiments by Lucas (1936) suggest that many plankton animals avoid light more actively in rich diatom cultures than in poor ones. This is a fairly good explanation of a vertical "animal exclusion" in rich phytoplankton areas.

Without entirely denying Hardy's theory, I am of the opinion that the cause of poor zooplankton in rich phytoplankton waters is often more simple.

First of all, it must be remembered that the creation of a zooplankton population demands conditions entirely different from those necessary for phytoplankton. When conditions for phytoplankton production suddenly change from bad to good, the capacity for rapid reproduction in phytoplankton (about 2 divisions in 24 hours) enables a few specimens to establish a very rich population in less than 10 days (cf. Steemann Nielsen, 1935 a, p. 42). But it cannot be the same with the zooplankton, since each individual must have a certain time to develop, a restriction that makes it impossible for the ordinary species to create a rich zooplankton population in 10 days. Secondly, it is by no means certain that a sudden change from bad to good conditions for developing phytoplankton should immediately create equally good conditions for zooplankton. The most important requisite, after all, is that mature or juvenile individuals should be present.

Nature, however, seems so arranged that good conditions for zooplankton always occur during normal phytoplankton maxima. A simultaneous growth of zooplankton always occurs in the oceanic water masses south of Iceland when the phytoplankton production has commenced. About one month after the beginning of this spring maximum there are large quantities of both zoo- and phyto-plankton, a fact which clearly appears from the "Dana" Station 4402 (62°23′ N., 16°05′ W.) on 25th June 1932, when both kinds were very rich (see Table 56, Steemann Nielsen, 1935 a); the volume of zooplankton in one haul with the 2 m. ring-trawl (50 m. wire) was 625 cm^3. At

the same position, in the beginning of May, 1934, shortly before the beginning of the spring maximum of phytoplankton, the zooplankton was less than 1 cm.[3]

For obvious reasons the zooplankton maximum will always come later than the phytoplankton maximum. A typical example is to be found on the Icelandic coasts; I have shown (1935 a) that the phytoplankton maximum occurs along the open coasts about the middle of May, while in protected fjords it arrives about one month earlier. Examination of the amount of zooplankton found about the middle of May, 1935, gives the following results (cf. Tables 4—5, St. N. — 1935 b): in the open Faxafloi, off Keflavik, a fairly poor stock of zooplankton consisted mostly of juvenile individuals, primarily of Cirripedian Nauplii. The inner part of the protected Hvalfjord, however, showed a rich zooplankton with numerous full-grown individuals — at 25 m. depth for instance 100 l. contained more than 3000 copepods. While the phytoplankton was just reaching its spring maximum off Keflavik, at Hvalfjord it was already on the decline. The temperature in Hvalfjord was several degrees below that of the waters off Keflavik, and temperature, therefore, could not be the controlling factor of the earlier development of the zooplankton population in the fjords.

Under normal conditions in northern waters production will, generally speaking, proceed as follows: At a certain moment the production of phytoplankton starts, and soon after the zooplankton begins spawning. During the phytoplankton maximum, which generally lasts for about one month in these waters, the majority of the plankton animals will be young individuals which are all growing up and which will not reach the full-grown stage before the end of the phytoplankton maximum. About this time the water will be rich in both phyto- and zoo-plankton, but at the same time the nutrient salts, phosphate and nitrate, will have been consumed by the phytoplankton and its production will fall off. Simultaneous "grazing" by the plankton animals will assist in creating a poor phytoplankton period, thereby causing a period of zooplankton preponderance or an apparent inverse relationship between the two kinds of plankton, in spite of the fact that conditions are not at all adverse.

In areas where the surface water is continuously renewed through rising of deep water the quantity of zooplankton cannot be expected to reach very high values. An apparent animal exclusion may thus be observed. A rather typical example of such conditions is to be found on the south coast of Iceland. On the edge of the shelf, here, oceanic deep sea water is continuously being forced to the surface as shown by the great quantities of the nutrient salts in the surface water throughout the summer, in spite of the continuously active production here of phytoplankton (cf. Steemann Nielsen, 1935 a).

This ascent of water from the depths is particularly noticeable near the Westmanna Islands where the shelf is fairly narrow, but it is also to be observed farther west although at a greater distance from the coast, because here the shelf is wider. Oceanic water which has risen

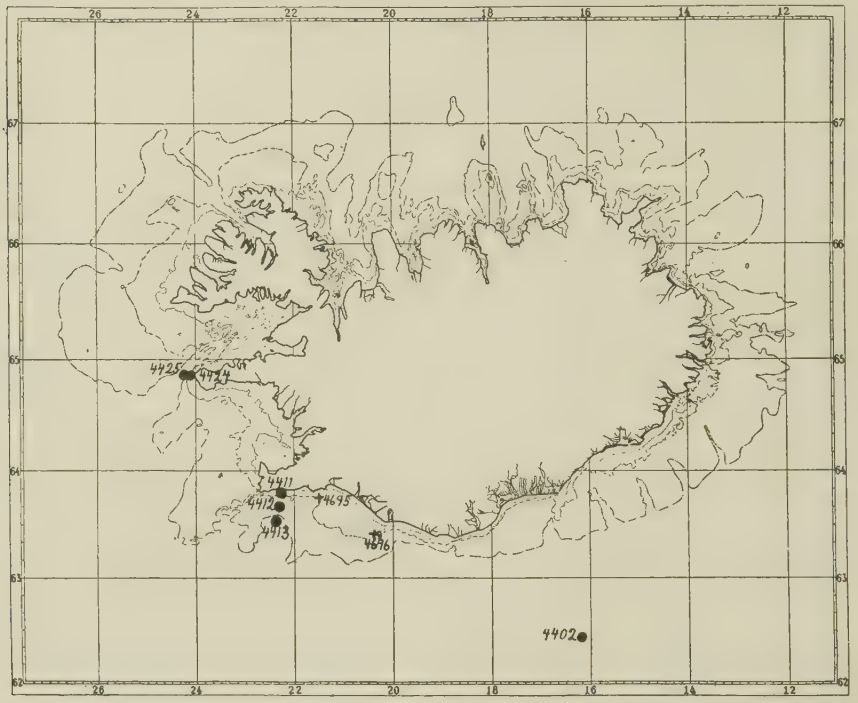

Fig. 1. Plankton stations at Iceland • 1932, + 1933. Depth contours are shown for 200, 100, and 50 m.

from the depths is poorly populated as regards both phyto- and zooplankton. Its richness in nutrient salts is of great and immediate value to the former, but the latter will not benefit until later.

The character of the currents along the south coast of Iceland is such that the waters in which production has been started are forced partly landwards and partly westwards along the coast, turning north at Reykjanes and continuing along the west coast of Iceland. A rich zooplankton, due to favourable feeding conditions, may thus be expected on the banks west of the Westmanna Islands and on the west coast also, as is actually the case.

In Table 1 the average volume of zooplankton is given for 15-minute hauls with a 2 m. stramin ring-trawl on 65 and 15 m. wire from the "Dana" stations S. and W. of Iceland about July 1st, 1932 (Fig. 1). The phytoplankton content (Peridinians + Diatoms + Coccolithophorides), and content of nitrate at the surface are also recorded. Stations 4411—13 give a section perpendicular to the coast west of the Westmanna Islands. The three stations were all rich in phytoplankton, but nitrate was found at the outer one only, and in such quantities that a definite mixing with deep oceanic water is indicated. The quantity of zooplankton appears to increase as the coast is approached, the innermost station showing about 10 times as much as the outer one. From Stations 4424 and 4425 on the west coast it may

Table 1.

Nitrate, phytoplankton, and zooplankton on the south and west coasts of Iceland about July 1st, 1932.

Stat.-No.	Position	Area	$N\text{-}NO_3$ mg./m.^{3} at the surface	Phytoplankton (D+C+P) in 100 cm.^{3} at the surface	Zooplankton. Average volume of 15-min. hauls with 2 m. stramin ring-trawl, 15 and 65 m. wire. (cm.^{3})
4413	63°34′N, 22°25′W	South coast, outer St.	40	120,000	25
4412	63°42′N, 22°17′W	„ „ middle St.	0	137,000	95
4411	63°49′N, 22°11′W	„ „ inner St.	0	175,000	200
4424	64°47′N, 24°02′W	West „	0	ca.10,000	2,550
4425	64°47′N, 24°13′W	„ „	0	12,000	450

be seen that nitrates cannot be traced in the surface, phytoplankton is rather poor, whilst the quantity of zooplankton has increased considerably. The small quantity of zooplankton at Station 4413 cannot be due to the more oceanic position, as is to be seen by studying a similar haul (wire length 50 m.) at Station 4402, well off the coast in true oceanic water; here the volume of zooplankton is no less than 625 cm.^{3}

The values from "Dana" stations in these waters at the end of August 1933 are given for comparison (cf. Fig. 1); unfortunately the zooplankton was measured in conjunction with phytoplankton and nutrient-salt content at two stations only. St. 4696, near the Westmanna Islands, is characterized by a strong admixture of deep oceanic water, indicated by large quantities of nitrate at the surface; consequently the phytoplankton is rich, and the zooplankton fairly poor. St. 4695 is situated near the coast but further west; nitrates were not traceable at the surface, the quantity of phytoplankton is considerably less than that at St. 4696, whilst the zooplankton quantity is very much higher. By the end of August 1933 conditions were thus exactly like those in early June 1932.

Plankton conditions near the Icelandic coast, of course, are far from being as simple as shown by the present schematic picture; the ascent of deep-sea water on the south coast does not mean an uninterrupted ascent of oceanic deep-sea water that expels all surface water; it only indicates a fairly regular admixture of deep-sea water to the surface water. The surface water, rich in nutrient salts, in the area of up-welling is a mixture of "old" surface water, originating from more easterly coasts, and "new" surface water, just ascended from below. The presence of zooplankton, therefore, is not at an absolute minimum; the quantity is small only on account of the heavy admixture of deep-sea water, poor in zooplankton.

Nothing prevents the possibility of finding comparatively large quantities of one species or another of plankton animals in the area of up-welling, if conditions have been optimal for such species in the "old" surface water. Other factors for the animals, for instance, the presence of spawning specimens, are of no less importance than

Table 2.

Nitrate, phytoplankton, and zooplankton on the south coast of Iceland at the end of August, 1933.

Stat.-No.	Position	Area	$N\text{-}NO_3$ mg./m.^{3} at the surface	Phytoplankton (D+C+P) in 100 cm.^{2} at the surface	Zooplankton. Average volume of 15-min. hauls with 2 m. stramin ring-trawl, 15 and 65 m. wire. (cm.^{3})
4696	63°25′N, 20°19′W	Off Westmanna Isls.	100	69,000	35
4695	63°36′N, 21°31′W	West of the Westm. Isls. near the coast.	0	35,000	265

food-conditions for the development of a population. Thus, no attempt has been made at analysing the composition of plankton volumes here used as an indication of quantities. Completely to understand the zooplankton production on the Icelandic coast necessitates a thorough investigation of the biology of the several species. The purpose of this paper simply serves to emphasize that a rich production of phytoplankton throughout the summer, on account of a steady supply of water rich in nutrient salts, does not necessarily signify the presence of large quantities of zooplankton, albeit generally presuming that quantity of zooplankton be directly related to quantity of phytoplankton. The effect of a large phytoplankton production on the zooplankton may appear somewhere else.

Conditions similar to those on the south and west coasts of Iceland undoubtedly exist in many other areas. For the North Sea, Savage and Wimpenny (1936) have shown that the largest quantities of zooplankton generally occur outside areas rich in diatoms, the so-called "diatom patches". When these consist of *Rhizosolenia styliformis,* they generally follow the inflow of Atlantic water, consisting, partly, of deep oceanic water which is being forced to ascend along the sides of the Faroe-Shetland Channel, thereby forming whirls (Jacobsen and Jensen, 1925, — Steemann Nielsen, 1935 a). This water is rich in nutrient salts which will favour a strong phytoplankton production, and the formation of "diatom patches" must therefore follow the inflow from the north into the North Sea. The incoming water, however, originating in part from greater depths, will not contain much zooplankton until it has penetrated some distance into the North Sea, by which time the phytoplankton minimum will have set in. Thus it follows that the larger quantities of zooplankton occur outside the diatom patches.

The proportion of juvenile animals must be high in such patches, as is the case during the greater part of an ordinary spring maximum as described above. Savage and Wimpenny show that the relative number of juvenile animals in the North Sea reached an optimum within the diatom patches, but their view that this may be due to a higher oxygen content within the patch seems incorrect since it appears from their data that the oxygen contents inside and outside these patches are almost equal.

At South Georgia, where Hardy (1935) has shown that large quantities of euphausids occur outside areas rich in phytoplankton, conditions are possibly similar to those near Iceland and in the North Sea. Hardy's theory that the horizontal displacement of euphausids is due to the vertical animal exclusion and to the difference of the currents in the upper and lower layers, cannot be disregarded, but is not altogether convincing in view of the fact established by Ruud (1932) that euphausids are two years old before they are fully developed, which tends to deny any relation between the occurrence of the full-grown animals and the phytoplankton present. The development of euphausids must have occurred at a time entirely different from that of the phytoplankton production.

Let us consider two neighbouring water masses, A and B. In A last year a production of euphausids took place simultaneously with a rich production of phytoplankton, while in B no production of animals is supposed to have taken place. This year examinations are made and for some reason or other a rich phytoplankton production is developing in B, but not in A; according to the past history of the water, there are no euphausids in B, while in A feeding conditions are now poor for these animals and the stock has therefore decreased to a minimum. In the boundary mixture, A—B, however, large quantities of euphausids would be expected on account of the good feeding conditions, as no individual is likely to die from starvation. Those are the lines along which I imagine a possible development in South Georgian waters. Hardy himself has established the fact that the largest quantities of euphausids occur on the boundaries of areas of rich and poor phytoplankton respectively. A similar explanation seems applicable to the facts established by Savage and Wimpenny (1936), that the largest quantities of copepods in the North Sea are to be found along the edges of diatom areas. In this connexion it is of no importance that the copepods are not two years old, as the antarctic euphausids must be; nevertheless a considerable difference exists between the ages of the copepods and the diatom patches.

Conclusion.

The essence of my opinion as to the cause of inverse relation between quantities of zooplankton and phytoplankton is that although there is some connexion between the amounts of zooplankton and phytoplankton, as the former depends for food on a good production of the latter, the slower development of a zooplankton population will delay the appearance of its maximum as compared with the time of the phytoplankton maximum. Moreover, on account of the currents in the sea, the two maxima may occur apart, even at considerable distances from each other.

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The Centrifugal Pump and Suction Hose as a Method of Collecting Plankton Samples.

By

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Introduction.

IT is now almost exactly fifty years since Hensen (1), referring to the difficulties in, and the objections to, the net method of collecting plankton, made the following remark: — ".... it will eventually be best, for the determination of the surface catches, to bring water by means of some sort of tube and pump, on to a filter ....". He then went on to explain that since, in the work upon which he was engaged, the experiments indicated sparse plankton at the surface, he had not spent more time in the construction of such a piece of apparatus, but that of all methods of collection for the purposes of quantitative analysis the pump would be best.

Since this statement, many zoologists have devoted attention to this fundamental and important subject. The very fact that planktologists have reverted to the problem frequently during the last half century, shows that many workers are still, in spite of modern improvements, dissatisfied with the methods in use. That the pump and suction hose method fulfils the ideal of perfection is not for a moment suggested, but we have recently given much time and thought to the problem, and with the results of some interesting experiments carried out last November available as evidence, it is proposed to review the position of this method of collection. Before giving an account of these recent experiments, a brief résumé of the work in this field over the last fifty years may be of interest, showing what developments have taken place, and giving the opinions of a large number of distinguished workers.

Historical Note.

After Hensen had made mention of the possibilities of the pump, little seems to have been done for about ten years, but in 1897 Dr. Frenzel (2), referring to Hensen's work of 1887, said that

".... This idea (pumping for plankton) appeared to me so simple and natural that I asked myself what reasons there could be for this method remaining so long untried ....". He made a special point of the use of pump and tube for obtaining plankton samples from beneath the ice — a very useful experiment which has yet to be tried with modern equipment — and he also pointed out that the apparatus could be used from a boat. His theory was, rightly enough, that as large a volume of water as possible should be drawn up and filtered, and he considered 500 litres a minimum. The pump he used appears to have been capable of dealing with 100 litres per minute, and Dr. Frenzel made a specially reinforced tube to avoid the flattening of a plain rubber tube due to suction. Such reinforced tubing is, of course, now commonly used and easily obtained. There is little doubt that Dr. Frenzel would have perfected the method in time but unfortunately he stumbled on a wooden jetty in the lake he was investigating and fell into the water, and although he managed to make his way to safety, the shock was too severe for his heart, and he died the following day. Science had lost a great man, and his work was unfinished.

In the same year (1897) Kofoid (3) discussed some of the sources of error in the plankton method and pointed out how the net filtration coefficient worked out by Hensen varied with the amount of plankton present in the water examined. He tested this by pumping and filtering a column of water equal to that passed by the net, and found that according to the abundance of the organisms the coefficient of the net would vary from 1·5 to as high as 5·7, thus demonstrating the impossibility of establishing a fixed coefficient. His next point was that a fully shrunken net might have 30 per cent. more meshes to the cm. than a new one, and that in the case of a fully shrunken net the aggregate area of the openings could easily be reduced by more than 50 per cent. Yet it is on nets of this type that the workers of today are trying to base quantitative results.

At about this time (1895—1903) a number of zoologists, among them being Kramer, Herdman, Wolf, Steuer, Murray, and Blackman, took samples of plankton from the surface layers by filtering the water passed through an ordinary steamship's pump, and their chief criticism seems to have been that only surface layers could thus be sampled. In 1901, however, Lohmann (4) used a tube to collect plankton from depths up to 100 metres. Here a very small tube was used, since it was the smallest forms only that he wished to study, and the quantity of water he obtained was only 75 to 100 litres and quite insufficient for zooplankton work. Nevertheless, his system seems to have been perfectly satisfactory for the phyto- and nanno-plankton, and he stated that the results are far more convincing than those obtained by the use of a net. A general review of the Hensen method was made in 1901 by Jenkins (5), but Lohmann's experiments had not at that time been published.

After this the matter seems to have lapsed for a time although Hensen refers to it again in 1912, and in 1916 Juday (6) gave

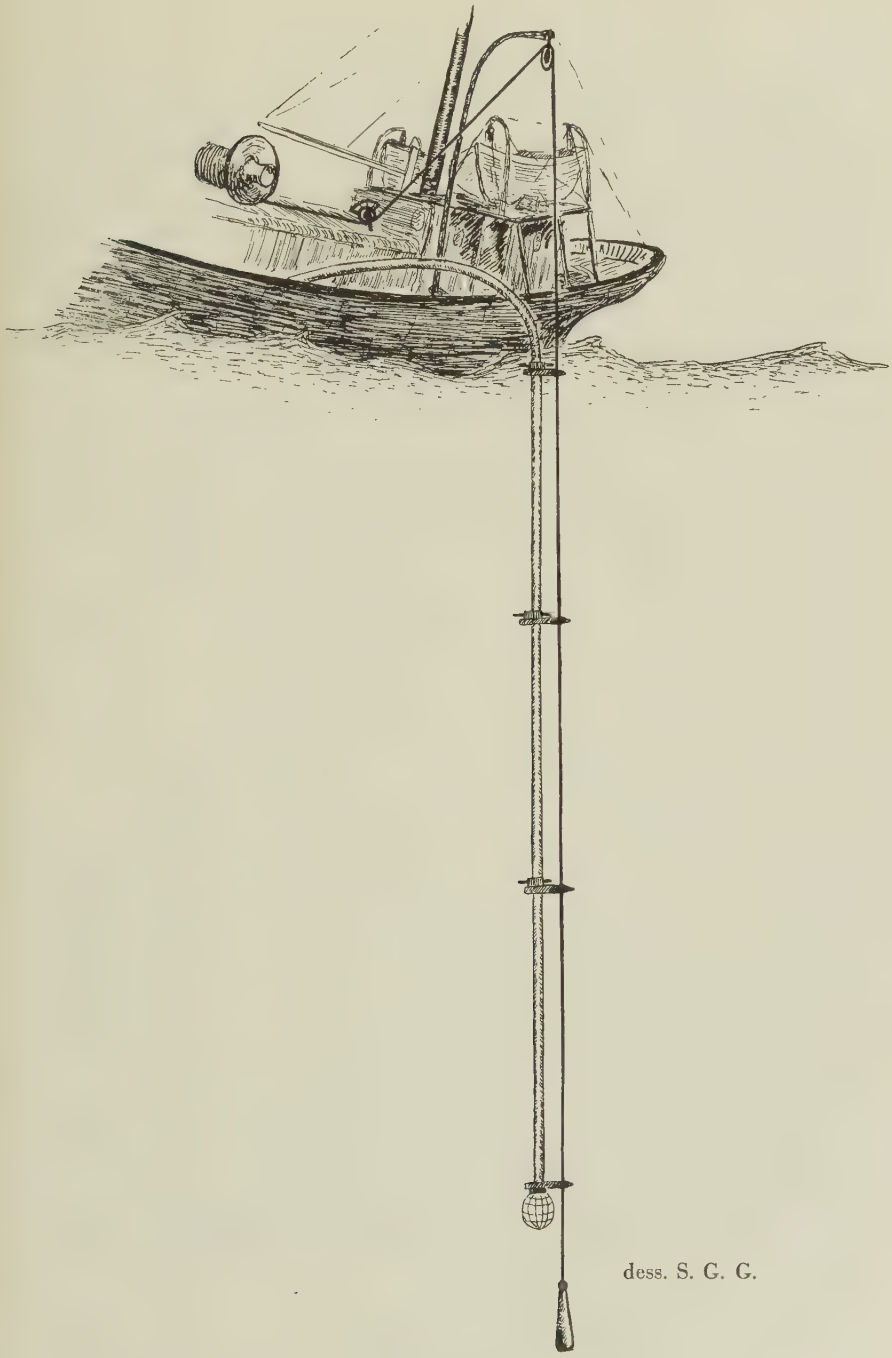

Fig. I. Suggested method of attaching jointed sections of hose to the weighted warp.

a general and very useful survey of limnological apparatus. During the last ten years, however, further work with suction apparatus has been done, and the method alternately praised and criticized. Among the more recent reports is the work of Robert (7) who compares pump catches with those made by a Nansen No. 12 net and points out that either net or pump might be used according as conditions and requirements indicate. He also quotes figures given by Hool comparing pump catches with those made by an Apstein net. As far as adverse criticism of the method goes, it must be pointed out that the critics refer chiefly to awkward apparatus and difficulty in handling rather than to inaccuracy on the part of a pump. The problem of the validity of hauls is mentioned by Gardiner (8) in 1931, and Hentschel (9), Kobuko (10) and Steemann Nielsen (11) all deal with the vexed question of plankton collecting.

The Apparatus and Method.

The problem of obtaining as large a volume of water as possible while at the same time keeping the pipe sufficiently small to handle, was obviously the starting point of the investigations, and it was decided that a three-inch hose would represent the maximum size to fulfil the requirements. The ideal aimed at was to draw up 5 cubic metres of water in less than fifteen minutes, and it was agreed that with the enormous suction at the mouth of the pipe no animal of reasonable size within its influence could escape, and that thus, knowing the volume of water filtered and the exact depth at which it was taken, the results would be quantitatively absolute. Enquiries were then made of some of the leading firms of pump makers in Britain as to whether such a pump was available, having in mind the use of about 100 metres of piping so that water to that depth could be sampled. An accompanying diagram (Fig. I) shows how sections of such piping could easily be attached to a steel warp, weighted with lead.

The firm of Messrs Ransomes and Rapier, Ipswich, kindly gave the data concerning power required, diameter of pipe, and so forth and as they had a new three-inch petrol-driven pump on the market, agreed to hire us the machine for experiment. At the time that the Fishery Research Vessel "Explorer" was available, however, the three-inch pump, which would give 18,000 gallons per hour, could not be supplied, so for the purpose of the first experiment it was decided that a two-inch machine giving 10,000 gallons per hour would suffice, and this pump, complete with fifty feet of suction hose and twenty-five feet of two-inch delivery pipe, arrived at Leith on November 7 and was fixed up on the deck of the ship (Fig. II). The Edinburgh Water Department authorities very kindly lent us a water-meter, so that an absolutely accurate knowledge of the amount of water filtered could be obtained. It was a Siemens meter of a semi-positive type, and although it did not appear to exert any obstruction to the plankton passed, it was shown later that a fair pressure was necessary to overcome its resistance to the passage of water, so that once the rate of

Fig. II. The Ransomes & Rapier two-inch pump on the H. M. S. "Explorer".

Fig. III. The filtering net about to be placed in the delivery stream from the Siemens water-meter.

flow of the pump was known most of the collections were made without the meter in circuit. The rate of flow of water was ascertained by pumping similar quantities of water out of the ship's deck tank, first with the meter in circuit and then without. The difference was so small that for all purposes it may be assumed that the meter had but little effect on the amount of flow per minute, and merely increased the pressure to be overcome by the pump. In a permanent installation, should a meter be required, it would be advisable to use a type with plain vanes and not a positive type. The vane-type meter offers no resistance to the water, and though less accurate than a positive type any small error would be constant for all collections and would thus be automatically cancelled.

The filtration of the water was carried out by placing a cone-shaped silk net of finest mesh in the delivery stream (Fig. III). This was allowed to lie on the deck, and not to hang, as in hanging the weight of water might break the silk. In a faster flow, should some cushioning effect be required, the filter could be placed in a tank, the delivery stream thus striking a cushion of water within the net instead of the net itself. This method of collection has already been referred to by Juday (6). Similar slight modifications could also easily be introduced at short notice as conditions and requirements dictated.

A small net about 30 cm. in diameter was found capable of filtering the flow very quickly, although made of the finest gauge silk. The suction force of the pump was tested under water in the ship's specimen tank, and found to be so strong that an iron bucket stuck to the inlet and could only be removed by wrenching it free. The last doubts as to the success of the experiment now rested on the all-important question as to whether the plankton animals could pass through a modern high-efficiency centrifugal pump working at about one thousand eight hundred revolutions per minute without being disintegrated beyond recognition. This point could be decided only by experiment, and it was with some trepidation that the work was begun outside the Bass Rock in the Firth of Forth on Monday, November 9. Great was the relief when the very first pump collection contained a few *Calanus,* not only undamaged, but still alive, and apparently none the worse for their unusual experience.

The Extent of the Tests.

During the next few days a survey of the Firth of Forth embracing fifteen stations was carried out. At each station a full range of horizontal and vertical nets was used as well as the Hensen egg net, which was used vertically. Six hundred gallons (2·7 cubic metres) of water were pumped from a depth of 12 m. and a similar quantity from just below the surface. These two depths were sampled by the pump at all stations, the 2·7 cubic metres of water being drawn in about ten minutes. This was a somewhat longer time than expected owing to the use of the two-inch instead of the three-inch pump. The

Fig. IV. A photomicrograph of part of a pump collection.

Fig. V. Part of a net collection after passing the pump at full speed, showing good condition of organisms.

larger instrument would supply the suggested 5 cubic metres of water in approximately the same time.

After pumping, the filtering net was washed out carefully into a jar, the collections thus obtained being preserved in formalin for later examination at the laboratory. It should be mentioned that in using a pump, care must always be taken to let it run a few seconds before beginning the collection, in order to remove the unwanted column of water from the pipe and replace it with water from the required depth.

Before dismantling, the pump was tested again for rate of flow, which was still constant, and finally a large collection of plankton of all sorts taken by a net was passed deliberately through the pump at full speed and collected at the delivery end. This was examined and the photographs (Figs. IV and V) show the wonderful condition of the most delicate forms, even larval fish being perfect. A large Pandalid over two inches long was rather broken but it is probable that in a three-inch pump even larger forms than this would be taken intact so that the question of smashing up general plankton can be disregarded except for large medusae, which could be prevented from entering the pipe by a large-meshed wire cage.

Practical Application of the Method.

Before quoting some of the results obtained, a word must be said as to the practical side of the method.

The lessons taught by the experiments were useful in the extreme and revealed in the technique certain points that could never have been decided other than by practice. In the first place, convenient as a petrol-driven pump can be it is certain that if the pump could be run by the ship's steam, much trouble would be saved, particularly in bad weather, and the outlay would be less. It was ascertained that such a pump as we have in mind could easily be run from the sounding winch on the ship, gearing up and using a silent chain drive.

The second point was the action of sea water on an ordinary iron pump, causing "furring up" of the impeller, and so a permanent pump would have to be constructed with gun metal casing and impeller. This would present no difficulties as such pumps are, we understand, already on the market.

The use of a meter is desirable, as the rate of flow with a full 100 metres of pipe would be materially slower than with a short length, owing to increased frictional resistance. As already mentioned, the vane type of meter would be the most suitable for a permanent installation. There is little to say concerning the working of the apparatus at sea. It is straightforward, and all that is necessary is to see that the joints in the pipe line are kept tight, as by constant twisting of the pipe they tend to become slackened unless tightly done up. The length of pipe which could be handled is greater than was at first thought, and sections of 15 metres at least could be dealt with, if not 20 metres. This would reduce the number of joints and clips to the supporting warp. In the experiment, the pipe was not fitted with clips

for the warp and was merely attached with rope, but the clips would make for quick and easy handling in a long pipe and could easily be fixed at the joints.

Far from being the "cumbersome outfit" some have suggested, it was found very easy to handle, and considering the absence of clips and the fact that the whole apparatus was only temporarily fitted up, it proved far more easy to deal with than had been anticipated. The engine of the pump was easy to operate and control, while the pump itself was efficient, self-priming and reliable.

Results of the Experiments.

The most outstanding feature of the collections was undoubtedly the number of small organisms, and the apparent scarcity of the larger ones. This is not due to an error in sampling, but to the fact that with a net, a very much greater column of water is involved, either vertically or horizontally, and although when plankton is scarce, the nets yield small collections, when plankton is abundant far more material is taken than is wanted except in the case of young fish work, for which, of course, the greatest possible amount is usually desirable and for which the large 2-metre ring net is undoubtedly a good instrument. Used in the comparatively sparse zooplankton which was encountered in November all over the Firth of Forth, the pump shows at once how really scarce the larger plankton organisms were in relation to the smaller forms. The following Table 1 illustrates this point.

Table 1.

Lat. 56°10½'N. Long. 2°32'W.	Hjort Net No./10,000 litres.	Standard Net No./10,000 litres.	Pump (12 m.) No./10,000 litres.
Calanus (female)	125	150	140
Sagitta	50	40	30
Clione	—	—	8
Amphipods	10	5	8
Copepods (All stages)	3,000	9,000	12,500
Medusae	Common	Very few	Absent

Phytoplankton.

Although not excessive, the phytoplankton was varied, and was taken in sufficiently large amount to render counting impracticable. As far as comparison with nets is concerned, the only net taking phytoplankton abundantly was the standard fine silk. For a qualitative comparison of phytoplankton species in pump and net collections we are indebted to Miss H. S. Ogilvie who compiled the following Table 2 showing the presence and absence of the chief phytoplankton forms in collections made at the same place and time. Although the net sampled all layers, it will be observed that almost all the forms taken by the net were also taken by the pump at one depth only, while a few species appearing in the pump collections were not seen in the net, and *vice versa.*

Table 2.

Comparison of Pump and Net Collections.

Pump, 12 metres. Standard F.S. Vert., 50 metres.

Area Bllc, 9/11/36. × = Present
— = Absent (i. e., not observed).

Diatoms	Pumps	Standard F.S.
Asterionella japonica	×	×
Actinoptychus undulatus	×	×
Bacillaria paradoxa	×	—
Biddulphia mobiliensis	×	×
Campylodiscus sp.	×	—
Cerataulina Bergonii	—	×
Chaetoceros affinis	×	×
„ *borealis*	×	×
„ *contortus*	×	×
„ *decipiens*	×	×
„ *didymus*	×	×
„ *scolopendra*	—	×
Coscinodiscus centralis	×	×
„ *concinnus*	×	×
„ *excentricus*	×	×
„ *radiatus*	×	×
Ditylium Brightwelli	×	×
Eucampia zodiacus	×	×
Guinardia flaccida	—	×
Hyalodiscus stelliger	×	×
Leptocylindrus denicus	—	×
Nitzschia seriata	—	×
Paralia sulcata	×	×
Pleurosigma spp.	×	×
Rhizosolenia alata f. gracillina	×	×
„ *shrubsolei*	×	×
„ *stolterfothii*	×	×
Sceletonema costatum	×	×
Stephanopyscis turris	×	×
Streptotheca thamensis	×	×
Thalassiosira gravida	—	×
„ *decipiens*	×	×
Thalassiothrix nitzschioides	×	×
Ceratium horridum	×	×
„ *furca*	×	×
„ *fusus*	×	×
„ *macroceros*	×	×
„ *minutum*	×	×
„ *tripos var. Atlantica*	×	×
Dinophysis acuta	×	×
„ *norvegica*	—	×
Peridiniopsis asymmetrica	×	×
Peridinium cerasus	—	×
„ *curtipes*	×	×
„ *depressum*	×	×
Phalacroma rotundatum	—	×
Prorocentrum micans	—	×

Tintinnids.		
Favella serrata	×	—
Parafavella denticulata	×	—
Ptychocylis urnula	×	×
Stenosemella nucula	×	—
Silicoflagellates.		
Distephanas speculum	×	×
Foraminifera	×	×

Filtration Coefficients.

Before discussing the zooplankton taken, it is necessary again to refer to the filtration problem. In the first place, any organism small enough to pass through the net meshes, even with difficulty, will not be suitable for a calculation of filtration coefficient. The comparison between pump and net of the numbers of such forms taken will serve to show what forms are partially or wholly lost, but that is all. In the second place every litre of water taken by the pump is filtered, so that the question of a filtration coefficient does not arise. By measuring the opening of the net and knowing the depth through which it has been hauled we can calculate at once the number of litres which would be filtered if filtration were perfect. This could only take place theoretically when the mesh is so large that there is no resistance to the passage of the net. The resistance set up by all nets, particularly by those of fine mesh, makes it necessary to divide the volume which would be filtered in perfect filtration by some figure unknown which is called the filtration coefficient of the net. We may designate this β. Now β can be estimated for each type of net, so that the volume filtered (V) is represented by the equation

$$V = \frac{\text{Number of litres in perfect filtration}}{\beta}$$

It will be obvious that the finer the mesh of the net, the greater will be the resistance, and so the larger β will become. If β were always constant for *any one net* many of the difficulties in the quantitative sampling of the plankton would be eradicated, but infortunately β may vary to an unknown extent from a variety of causes, at least one of which is beyond control. These causes are:— 1. Variation in hauling speed due to the movement of the ship, or other cause. This is not serious and can be standardized for a particular type of net. 2. Shrinkage of net with use. As we have already shown, K o f o i d's work indicates that this is very important, and it is a factor not easily overcome, since the β of a net must increase with age. 3. The clogging of the net by organisms. This is the most serious of all, for it will vary according to the abundance of plankton, and K o f o i d has shown that in this way β may become as much as four times as great as it should be. This introduces *at once* the possibility of a 400 % error before quantitative work in the laboratory begins.

Clearly, then, in a net, it is desirable to keep β as low as possible, and the ideal condition is approached as β approaches unity. Since the dinoflagellate *Ceratium* was retained equally well by the standard silk net and by the pump filter, a quantitative count would give a measure of the filtration coefficient of this net. The calculation was undertaken by making a count of the total number of *Ceratium* in each case from collections at a shallow station (18 m. deep) where there was no likelihood of uneven vertical distribution. The results are shown here, and could only be made from shallow water stations since at a deeper point layering of the water might occur, causing uneven vertical distribution which would vitiate the results in comparing net and pump collections (see Gardiner on validity of vertical hauls).

The material was collected simultaneously by pump and net working less than 20 feet apart, in dead calm weather and smooth water, so that vertical steady hauling gave the net the best possible conditions for fishing. The results were as follows:—

Pump collections 36/1645 and 1646, from surface and 12 m. deep respectively were mixed together, representing filtration of 5·4 cubic metres. This was diluted to 2325 c.c. and a 10 c.c. sample taken after well mixing. The *Ceratium* were counted, and the operation repeated twice for a check:—

1st count	138	
2nd „	146	Total = 416
3rd „	132	

Next the standard collection 36/1639 was taken, representing the filtration of 3·528 cubic metres at perfect filtration. Again three counts of the *Ceratium* in a 10 c.c. sample were made after diluting the collection to 2325 c.c.

1st count	52	
2nd „	50	Total = 153
3rd „	51	

To compare pump with net, volumes had to be adjusted:—

Pump 5,400 litres, Net 3,528 litres. Therefore number of *Ceratium* from 3,528 litres by pump would be $\frac{416 \times 3528}{5400} = 273{\cdot}27$. Thus the filtration coefficient of net $= \frac{273{\cdot}27}{153} = 1{\cdot}786$, so that a standard silk net *working under these conditions* was collecting only a little more than half the amount of plankton located in its path. This figure, as already pointed out, is bound to be of a very variable nature for the reasons mentioned, and although Gardiner (8) states that in a vertical haul speed of hauling makes little difference in the quantity of plankton caught, we incline to the view that this could only be the case in a net with very low filtration coefficient, and that in fine-mesh nets of high coefficient, speed of hauling is of extreme importance. This is suggested as a field for further work.

As regards the escape of forms through the meshes of the filter used for the pumped water, it must be borne in mind that such escapes

will of course take place. For the purpose of the calculation shown above, however, this will not affect the result. In the first place the mesh is fine enough to retain all the *Ceratium*, and in the second place escapes would be similar under these circumstances since both pump filter and net were of the same mesh silk. For filtration coefficients of other nets, large animals must be considered. Ultra-fine-mesh filters for the pumped water, or part of it, could be used for the study of nannoplankton, and this is the aspect of pump work upon which many workers have concentrated in the past. In the experiment under consideration, however, it was decided to use a filter of ordinary fine silk so that rapid filtration of large volumes of water would be ensured.

Comparison of figures in the following Table 3 shows total catches per 10 cubic metres for the zooplankton forms in pump and Hensen egg net, the volume filtered by net being calculated as perfect, i.e., with no filtration coefficient. At all stations comparisons are more or less similar, so that only three are given here.

Table 3.

1. Depth 12 metres.

Lat. 56°03′N. Long. 2°52′W.	Pump near surface 2,700 litres		Pump at 11 m. 2,700 litres		Hensen Egg Net, 12 m. 4,620 litres	
	Actual Numbers	No./10,000 litres app.	Actual Numbers	No./10,000 litres app.	Actual Numbers	No./10,000 litres app
Pleurobrachia	—	—	5	19	29	60
Calanus (female) ...	—	—	—	—	—	—
Sagitta	—	—	3	11	—	—
Calanus	—	—	2	8	—	—
Copepods (All stages)	1,500	5,800	130	500	—	—

2. Depth 40 metres.

Lat. 56°07½′N. Long. 2°52′W.	Pump near surface 2,700 litres		Pump at 12 m. 2,700 litres		Hensen Egg Net, 40 m. 15,400 litres	
	Actual Numbers	No./10,000 litres app.	Actual Numbers	No./10,000 litres app.	Actual Numbers	No./10,000 litres app.
Calanus (female) ...	1	4	3	12	145	95
Sagitta	5	19	3	12	40	27
Copepods (All stages)	1,200	4,600	3,000	11,000	180	126
Aglantha	—	—	—	—	Abundant	

3. Depth 50 metres.

Lat. 56°10½′N. Long. 2°32′W.	Pump near surface 2,700 litres		Pump at 12 m. 2,700 litres		Hensen Egg Net, 50 m. 19,250 litres	
	Actual Numbers	No./10,000 litres app.	Actual Numbers	No./10,000 litres app.	Actual Numbers	No./10,000 litres app.
Calanus (female) ...	21	80	37	140	130	65
Sagitta	6	23	8	30	68	34
Clione	1	4	2	8	—	—
Amphipods	3	12	2	8	2	1
Copepods (All stages)	2,580	10,000	3,300	12,500	300	150
Medusae	—	—	—	—	Abundant	

The numbers are per 10 cubic metres of water filtered, and since we are assuming for this purpose that the filtration of the net is complete, and β therefore equal to unity (which it cannot be) it is clear that where figures in the net column are higher than those in the pump the discrepancy must be due to deeper distribution not sampled by the pump (*Calanus* and *Sagitta*). On the other hand the high figures for Copepoda (all stages) in the pump column compared with the low one in the Hensen net may be a measure of the coefficient or of the escape of nauplii or a concentration of nauplii in the pump region.

An attempt to get a coefficient for the Hjort net was made as follows:— Collections from a shallow station (12 metres) were taken. The pumped material consisted of two "hauls", each the result of the filtration of 2,700 litres from two depths, added together, making in all 5,400 litres. The Hjort net had passed through a column representing a volume of 6,930 litres. From these two batches of material, the number of copepodids of all species together were counted to the nearest 10. In the pump there were 3,480, and in the net 2,830. Reducing the net figures from 6,930 litres to 5,400 litres, we get the number in the net at 5,400 litres to be 2,052. Thus the number of copepodids in the pump divided by the number in the net for a similar volume gives us a figure for the filtration coefficient in this case — $3480 \div 2052 = 1{\cdot}69$. Copepodids only were considered, since all copepodids encountered by the Hjort net are retained, while many smaller nauplii pass through.

Finally, a list of zooplankton forms has been compiled for corresponding pump and net collections. This is given below.

Table 4.

Zooplankton Species in Pump and Hjort Net at same Place and Time.

	Pump	Hjort Net
Calanus finmarchicus adults	×	×
„ „ copepodids	×	×
„ „ nauplii	×	×
Temora longicornis copepodids	×	—
Oithona spinirostris	×	×
„ *helgolandica*	×	×
„ nauplii	×	—
„ egg masses	×	—
Pseudocalanus minutus copepodids	×	×
„ „ adults	×	×
Acartia clausi adults	×	×
Centropages typicus	×	—
Microsetella sp.	×	—
Microcalanus pusillus	×	×
Lamellibranch larvae and post-larvae	×	—
Pleurobrachia pileus	×	×
Limacina retroversa	×	×
Clione limacina	×	×
Sagitta elegans	×	×
„ *setosa*	×	×

Aglantha sp.	×	×
Balanid nauplii	×	—
Cumaceans	×	×
Themisto	×	×
Larval Syllids	×	×
Tomopteris sp.	×	×
Young Gastropods	×	×
Trochophores	×	—

Conclusion.

The results and the information gained from the experiment may be summarized as follows:—

(1) The pump method is practicable, simple, successful, and accurate, especially for small forms, but also for quite large forms when they occur in sufficient numbers.

(2) Its outstanding advantage is in quantitative work, for which is is unrivalled.

(3) It is not excessively expensive, can be operated easily, and the apparatus should stand up to hard wear.

(4) Exact depths and volumes filtered are known precisely.

(5) There need not be, and indeed should not be, any question of a pump to replace all nets. The nets that must at all costs be retained are those of larger mesh which filter huge quantities of water in our search for less abundant forms, most particularly larval fish.

It must be remembered that even in dense patches, zooplankton forms may be as scarce as about one of a species per 5 litres of water, so that the use of a pump for less frequent forms is not to be recommended, since even 5 cubic metres of water is a comparatively small amount.

The following table shows the number of cubic metres of water filtered in four types of net, per 10 metres of vertical hauling, and gives us a clue as to why the large ring-net is good for catching larval fish. It covers about ten times as much ground as the others.

Large Ring Net (2 metre cheesecloth)	31·43	cubic	metres
Hensen Egg and Hjort Nets	3·85	„	„
Standard Fine Silk Nets	1·96	„	„

It is thus clear that in a 100 metre haul, the large net can deal with over 300 cubic metres — a very big volume — and therein lies its success for qualitative work. It is maintained, however, that for accurate quantitative work on the important small forms such as copepods, decapod larvae, and phytoplankton, the pump method is better than any method of net collection, and its adoption is strongly recommended.

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An Electrical Plankton-Net Closing Device.

By

Richard Van Cleve.[1])

HALIBUT eggs have been found to be so sparsely scattered in the North Pacific, even in the immediate vicinity of the spawning banks, that horizontal net hauls of one hour's duration with nets of one metre diameter at the mouth are necessary to obtain significant results as to presence or absence (see Thompson and Van Cleve, 1936[2])). Quantitative investigation of their distribution by means of closing nets therefore requires the use of the same type of haul. Because of the inefficiency and uncertain functioning of the net-tripping devices that are available, all of which are activated by messengers, the machine described below was built and has been used successfully during January 1937.

A total of 25 hauls was taken using this mechanism for opening and closing a one-metre net at depths of from 50 to 400 metres. Under the most trying conditions of heavy seas and strong tides it worked perfectly. Bad weather in which work of all kinds was necessarily suspended was the only limiting factor making more hauls with the machine impossible.

A sketch of the general plan of the mechanism is shown in Fig. 1. The machine is extremely simple, using a solenoid as the activating mechanism as is common in many types of electrical devices. The solenoid (A in Fig. 1), designed by Professor George E. Smith of the Department of Engineering, University of Washington, is 6 inches long, 4 inches in diameter, and wound with about 1,170 turns of No. 13 (Stub's gauge) cotton-covered enamelled (S.C.E.) wire around a brass tube large enough to accommodate the soft iron piston (B). The wire is enclosed in a chromium plated iron case filled with tar to make it waterproof. The piston (B) is 1 inch in diameter and 6 inches long over all. In order to increase the pull the inner end of the piston is bevelled and fits into a plug in the upper end of the solenoid tube. Both plug and piston are bored to furnish a passage for the water when the piston moves, forcing it in or out. Applying 32 volts through a resistance equivalent to 3 of these solenoids in series with one mile of No. 10 copper wire, a pull of 7 pounds was registered by the piston when ½ inch out from the plug. Applying 110 volts, a pull of 32 pounds was obtained. A brass or aluminum washer on the inner

[1]) Published by permission of the International Fisheries Commission of the United States and Canada.

[2]) International Fisheries Commission. Report No. 9, Seattle, Washington, 1936.

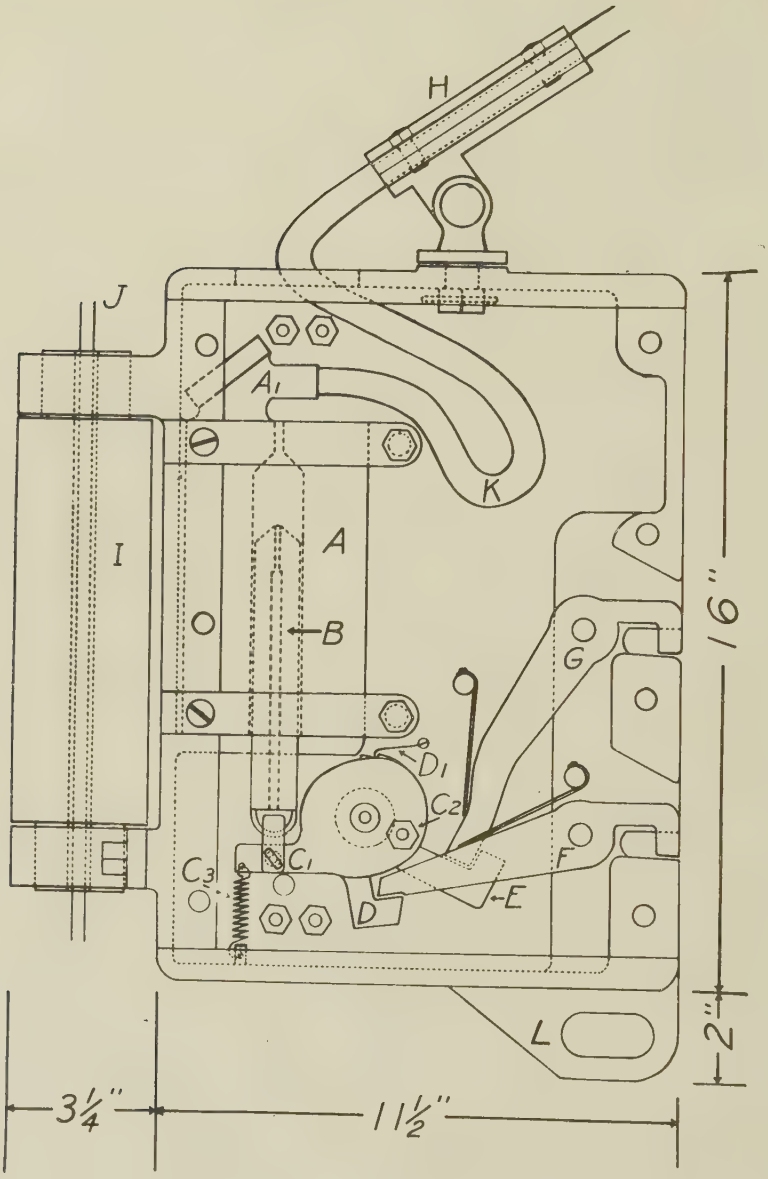

Fig. 1. Sketch of the net-releasing mechanism with the left side of the frame casting removed. Another cable clamp similar to H will be included on the bottom of the other machines to be used above the one illustrated. The bottom clamp will hold the electric cable leading down to the next machine below.

surface of the plug keeps the piston from touching the plug and sticking.

The machine which is shown with the side plate of the frame casting removed consists of a gunmetal case which swings on a long

cable clamp (I) which in turn clamps on the cable (J). The solenoid (A) is held in a vertical position with the electric cable (K) (No. 10, 2 conductor rubber-covered) leading out through a hole in the upper end. This cable is clamped securely in H which turns freely in all directions. About one foot of slack cable is left inside the case so that no strain is put on the solenoid connexion (A_1).

Beneath the solenoid the piston (B) is connected to the arm (C_1) of the double tripping device which consists of three disks mounted on one bolt. The outer disk as shown in the sketch bears the arm C_1 while the two behind it bear the catches D and E. A pin (C_2) mounted on the outer disk lies in the end of a groove in the disk of the catch D, so that when the current is applied and C_1 is pulled upwards D is rotated enough to release the lower arm (F). The spring catch (D_1) on top of D keeps it from swinging back when the arm is again pulled down into the set position by the spring (C_3) so that the pin (C_2) slides back along the groove and drops through a hole in the disk of the catch D into a hole in the catch E. Thus when the piston again pulls C_1 upward the second trip (E) is rotated releasing the upper arm (G). A light spring was attached to the upper catch (E) to make sure that it did not trip with the catch D due to friction between the heavy disks of C_1, D, and E.

The mechanism is cocked through an opening in the side of the casting by first rotating E until it holds the arm G. Then pulling out the pin (C_2) D is rotated to engage the arm F. The net is held closed when put out by a noose rope attached to the lower arm (F) and opens when this arm is tripped. The tow-rope is attached to the upper arm (G) and when this is released by tripping the mechanism a second time the net is closed by a noose rope attached to the loop (L) on the bottom of the machine.

To relieve the strain on the electric cable due to its resistance when towing through the water it is supported at 50 or 100-metre intervals by clamps resembling heavy burette clamps which are fastened to the towing cable. The electric cable is held between two broad jaws smoothed and rounded off to prevent cutting of the rubber covering. The clamp arm is mounted on a small cable clamp in the same manner as the tripping device, to allow for the twisting of the towing cable. No trouble was experienced with snarling of the two cables as long as the boat was kept moving.

The weight of the first machine complete is about 150 pounds but the construction can be made lighter by the use of thinner castings of stainless steel. More efficient double tripping mechanisms requiring less power to operate are also contemplated. With a strong towing cable and sufficient electrical power it is planned to use these tripping devices in batteries of 3 or 4 placed 50 metres apart on the towing cable. Quantitative hauls will then be made simultaneously at several levels with a marked saving of time which in the north-eastern Pacific is of great importance, since good working weather is usually limited during the winter months.

A Fifteen-Gallon Water-Bottle.

By

Richard Van Cleve.[1])

THE use of a constant-temperature apparatus for the experimental rearing of halibut eggs has made it necessary to devise a convenient method of obtaining comparatively large quantities of sea water (several hundred gallons at a time) from the depths at which the eggs normally develop. After a consideration of the cost of construction and ease of operation of different types of apparatus, including various types of pumps, it was concluded that a water-bottle of large capacity would be the most efficient in obtaining water from the required depths of 50 to 200 fathoms.

Because of the size of the mechanism and the conditions under which it was to be used, its structure was necessarily very heavy, its weight coming to 235 pounds when empty. This has not been found to be excessive, however, and while it is difficult to handle in very stormy weather it has been successfully used in the Gulf of Alaska throughout the winter season.

The plan of construction is shown by the sketch in Fig. 1 which includes the details of the mechanism within the upper lid. Fig. 2 shows the bottle in the open and closed positions. The cable clamps are seen to the right on the upper and lower collars.

Specifications for the bottle are:—

Water capacity — 15 gallons (56·8 litres).
Total length over all — 68 inches (172·7 cm.).
Weight of bottle complete (without water) — 235 pounds (106·6 kg.).
Diameter of cylindrical portion of bottle — 10¾ inches (27·3 cm.).
Length of cylindrical portion of bottle — 36 inches (91·4 cm.).
Diameter of end opening — 5½ inches (14·0 cm.).

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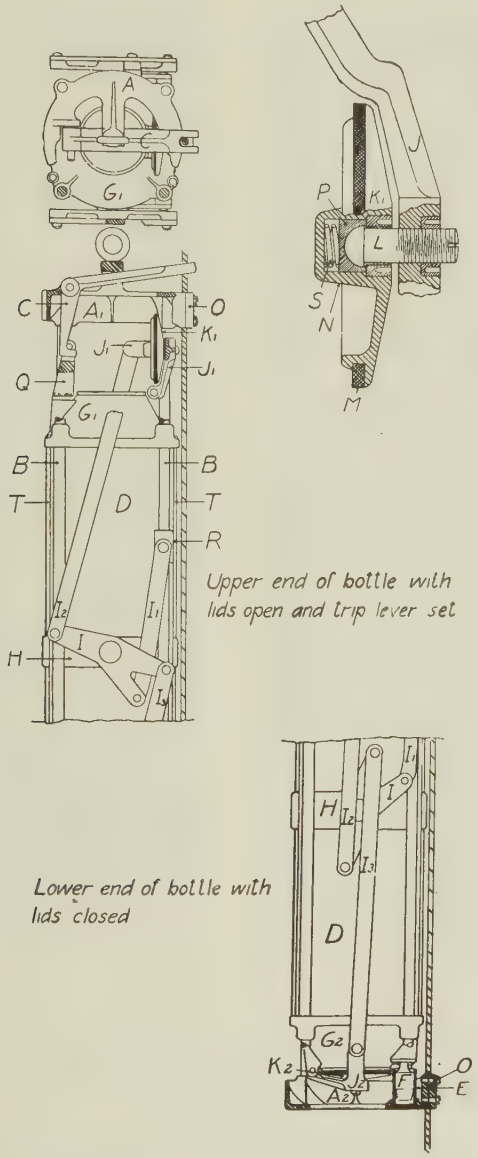

Fig. 1. Sketch of the general plan of construction. The details of the suspension of the top lid are shown to the upper right.

The essential features of the bottle are a rigid outer frame consisting of two bronze ring castings (A_1 and A_2, Fig. 1) bolted one at either end of four heavy stainless steel rods (B), and a cylindrical bottle (D) of slightly over 15 gallons capacity which slides up and down upon the rods. Hinged lids (K_1 and K_2) mounted on the end castings

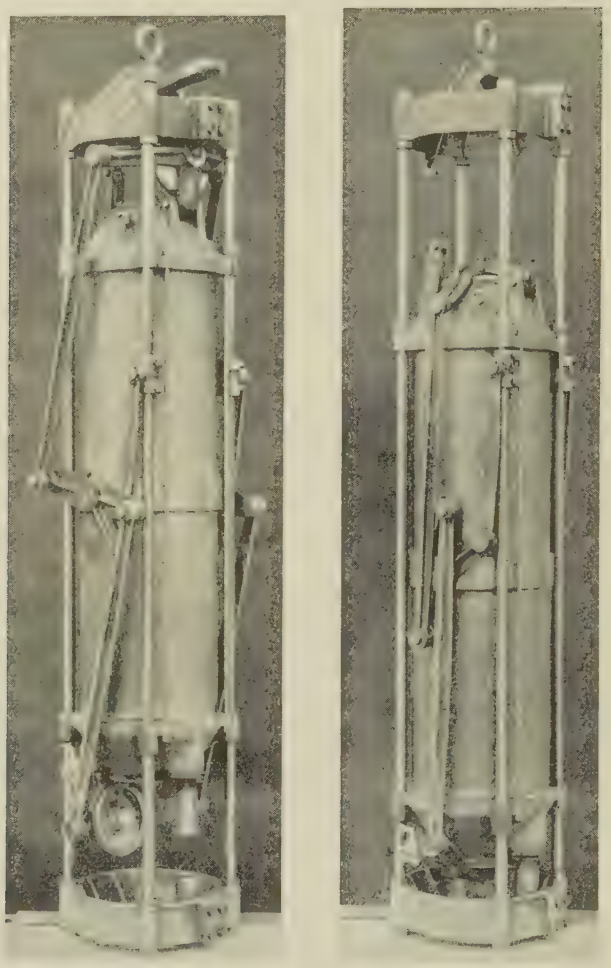

Fig. 2. Photographs of the bottle in closed (right) and open (left) positions.

(G_1 and G_2) of the cylinder are opened and closed by means of two bell cranks (I) which are mounted on either side of the centre band (H) of the cylinder and attached to the lids by connecting rods (I_2 and I_3) and the arms (J). A driving rod (I_1) from each of the cranks is clamped to the frame (B) at R. The movement of the bottle up and down on the frame activates the bell crank mechanism.

The bottle is attached to the cable by a clamp (O) on each of the ring castings A_1 and A_2. When the bottle is ready to be put overboard the cylinder is slid up on the frame and is hung by the roller (Q) upon the hook of the trip lever (C), thus opening the lids (Fig. 2, left). When the trip lever is struck by a messenger the cylinder is dropped, and it slides down the frame thus closing the lids (Fig. 2, right). It comes to rest with its entire weight hanging upon the two driving

rods (I_1), and the weight is transmitted to the lids through the bell crank mechanism, effectively sealing the water sample within the cylinder.

The small cylinder (E, Fig. 1, lower right) which is an integral part of the lower end casting (A_2) of the frame receives the piston (F) which is mounted on the lower end (G_2) of the bottle, and acts as a hydraulic shock-absorber. The mechanism is thus relieved of the shock which would otherwise result from the fall of the heavy bottle.

A spring (S, Fig. 1, upper right) is placed beneath the piston (P) within the cylinder (N) in the upper lid (K_1) in order to facilitate the seating adjustment. The spring makes it possible to adjust the top lid to seat first, when the bottle closes, and then by the compression of the spring the weight of the bottle comes to rest upon the lower lid. Both lids are free to rotate through a small angle in a vertical plane on the head of the set screw (L) in order to ensure proper seating, and a rubber washer (M) is provided to make a tight seal when the bottle is closed.

The entire outer surface of the bottle and all of the working parts are heavily nickel plated. All the inner surfaces including the lids and spigots which come into contact with the water sample are heavily silver plated.

A reversing frame for thermometers was not included on the original bottle but could be added with very little extra cost.

The details of construction and design of the bottle have been carried out by the Northwest Instrument Company of Seattle, Washington, U. S. A.

A New Form of Hensen Net Bucket.

By

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THE type of Hensen net bucket which has been used for the English fishery investigations since pre-war days (Figure 1) has two disadvantages.

In the first place a heavy catch takes a long time to drain. This is particularly so if organisms such as *Phaeocystis* are present. In this case the catch is generally drained twice, first by allowing the superfluous water to drain through the base of the net and the silk windows of the bucket, and again when the draw-tap is opened and the liquid in the base of the bucket is filtered through a silk cone, which in turn is washed into the jar in which the sample is preserved.

The other disadvantage is the choking of the draw-tap by large or small jellyfish. Such an obstruction may have to be cleared repeatedly by pushing a pencil up the tap. This procedure not only wastes time, but often results in an unexpected cascade which spills the catch being filtered through the silk cone and spoils the sample.

To meet these objections a modified bucket has been made for us by Messrs. Elliott and Garrood, Ltd., of Beccles, Suffolk. Like the previous type, it is made of brass and has an internal diameter of 14 cm. and a depth of 22 cm. (Figures 1 and 2). It differs in that the side windows, formerly of silk, have been replaced by transparent celluloid (Figure 1, c.w.). This lost area of filtration has been replaced by a disk of silk which is clamped over a detachable bottom made to screw on by a quick thread. The four windows of the old bucket were 12×10 cm. and gave a filtration area of 480 cm.^{2} compared with 154 cm.^{2} in the case of the new bucket, where the whole filtration is carried out by a disk 14 cm. in diameter. This diminution of 326 cm.^{2} in filtering area is very small compared with the area of the whole net, and it is not thought that it will appreciably affect the filtration coefficient. The details of the construction may be better understood by a consultation of the scale drawings in Fig. 2 and of Fig. 1. It will be seen that the double ring which holds the bucket to the net fabric

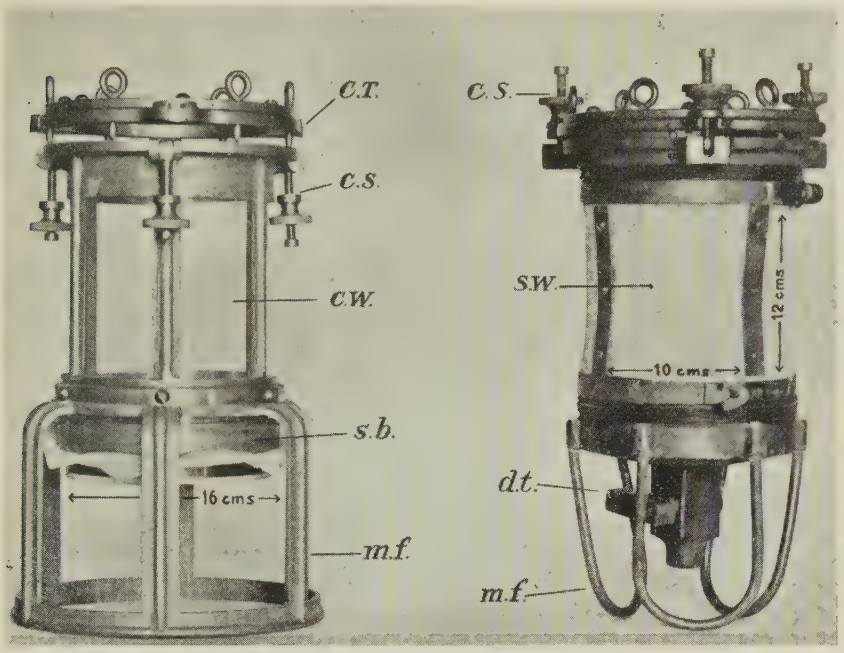

Fig. 1. On right the old type of Hensen net bucket and on left the modified form. c.t., clamp-ring; c.s., clamp-ring screw; c.w., celluloid window; s.w., silk window; s.b., screw-bottom; d.t., draw-tap; m.f., metal fender.

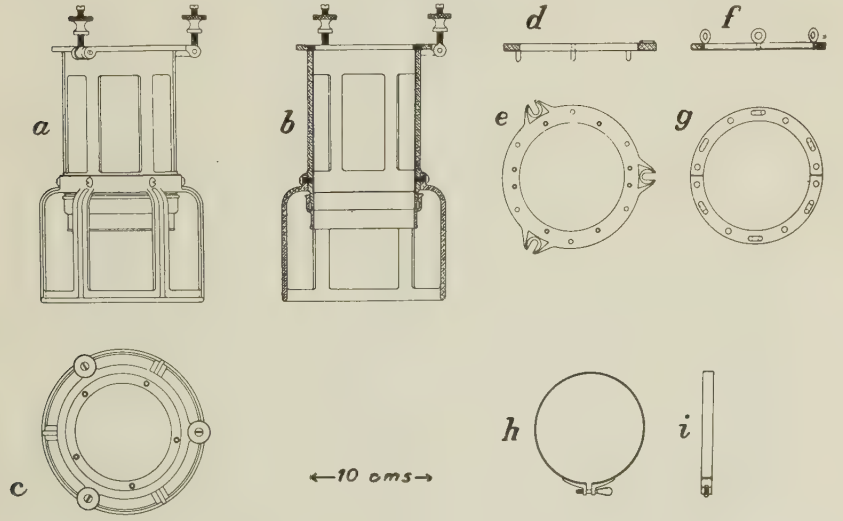

Fig. 2. Working drawings of the new bucket. a., side elevation; b., vertical section; c., in plan from above; d., lower clamp-ring in vertical section; e., lower clamp-ring in plan from above; f., upper clamp-ring in vertical section; g., upper clamp-ring in plan from above; h., clamp for silk used on screw bottom from above; i., clamp for silk used on screw bottom, side view.

Fig. 3. Hensen net rigged for working with the new type of bucket.

and to the rope guys (Figs. 2 and 3) is the same as in the old bucket. Above the detachable bottom, however, a metal fender-ring is joined to the body by four arms producing a rather heavier protection for the bottom of the bucket than that which is provided in the old type.

The new bucket has been in continuous use for the plankton investigations made from Lowestoft during the last two and a half years and it has given general satisfaction. Choking, of course, cannot take place and the bucket filters rapidly, even in difficult samples such as those containing *Phaeocystis*, if the underside of the silk disk is rubbed with the finger. In the case of the very heavy catches of big diatoms, such as *Rhizosolenia styliformis*, the filtration is rapid, and the catch is left on the silk disk as a thick paste which may be readily and conveniently transferred to the sample jar. While all this saves time, an even greater advantage has been found in keeping one or two spare detachable bottoms for each bucket. In this case, when consecutive hauls are being worked, the net can be rapidly sluiced and a clean detachable bottom put on, the original one being dealt with whilst the net is fishing the next haul.

Über die Scholle *(Pleuronectes platessa)* an der lettländischen Ostseeküste.

Von

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1.

In seinen umfassenden Untersuchungen über die Plattfische der Nord- und Ostsee hat Dr. Kändler — Hamburg den Hauptteil seiner Arbeit der Scholle *(Pl. platessa)* gewidmet. Dementsprechend hat er auch seine Forschungen über das Auftreten von Wirbelanomalien bei Pleuronectiden vorzüglich an dieser Art durchgeführt. Er ist hierbei zu Schlussfolgerungen gelangt, welche in wesentlichen Punkten mit den von Mannsfeld bei seinen Untersuchungen an Flundern (*Pl. flesus*) der lettländischen Ostseeküste gewonnenen Ergebnissen übereinstimmen (cf. Mannsfeld, 1934, Kändler 1935).

Gelegentlich der Flunder-Untersuchungen des Verfassers, über die demnächst auch noch ausführlich berichtet werden soll, konnte eine allerdings nur geringe Anzahl von *Pl. platessa* untersucht werden. Die hierbei erzielten Resultate dürften jedoch einiges Interesse finden, da das bearbeitete Material aus dem nordöstlichen Grenzgebiet des Verbreitungsraumes der Scholle in der Ostsee stammt.

Die Häufigkeit der Scholle in den einzelnen Gebieten der mittleren Ostsee wird durch folgende Zahlen über die Erträge der Schollenfischerei im Jahre 1928 charakterisiert (n. Kändler 1931).

Vorpommern	—	3,566,000 kg.
Hinterpommern	—	483,000 „
Danziger Bucht	—	17,000 „

An der Küste Lettlands ist die Scholle bisher nur als Beifang in Flunderfängen aus der offenen Ostsee beobachtet worden. Im Rigaschen Meerbusen fehlt sie vollständig. Der bisher festgestellte nordöstlichste Verbreitungspunkt an der Küste Lettlands liegt beim Leuchtturm Užava (Hasau), etwa 21°15′ O. und 57°15′ N. Einigermassen regelmässig kommt die Scholle noch in den Flunderfängen bei Liepāja (Libau) und seltener bei Pavilosta (Paulshafen) vor; weiter nördlich wird sie nur noch selten in einzelnen Exemplaren beobachtet (Mannsfeld 1934, 1936). Ihr Anteil an den in Liepāja gelandeten Flunderfänger über-

steigt jedoch im Jahresdurchschnitt kaum 1 %; er erreicht sein Maximum während der Herbstmonate, gewöhnlich im Oktober, zu welcher Zeit in einzelnen Fängen bis 10 % Schollen neben vereinzelten Klieschen (*Pl. limanda*) beobachtet werden. Dieser höhere Anteil der Schollen in den Herbstfängen dürfte auf die dann eintretende Hinausverlegung der Flunderfischerei vor Liepāja auf die ferneren, tieferen Fanggründe zurückzuführen sein. Schätzungsweise ergibt sich für die lettländische Ostseeküste im Vergleichsjahr 1928 ein Schollenertrag von rund 1000 kg.

Die Verbreitungsgrenze der Scholle fällt somit ziemlich genau mit dem Grenzgürtel zwischen dem SO.- und dem NO.-Faunengebiet der Ostsee zusammen. Sie ist etwa durch die gleiche Linie gegeben, die Möbius und Heincke als Nordgrenze für die Verbreitung der Makrele (*Scomber scombrus*) zeichnen (Mannsfeld, 1937).

Das für nachfolgende Untersuchungen zur Verfügung stehende Material bestand aus 45 Exemplaren von *Pl. platessa*, die aus einem am 1. September 1933 vor Liepāja gefischten Flunderfang von etwa 150 kg. ausgelesen waren. Die Bearbeitung derselben erstreckte sich auf eine Altersgruppen-Analyse und auf eine Untersuchung der Wirbelsäule, als des charakteristisch variierenden Merkmals.

2.

Der untersuchte Schollenbestand setzte sich aus Individuen zusammen, die zu den Altersgruppen II bis V und darüber gehörten. Wegen des augenscheinlich sehr geringen Zuwachses der älteren Schollen und der damit verbundenen Unklarheit der Otolithen war eine einwandfreie Altersbestimmung über die Altersgruppe V hinaus nicht durchführbar, sodass alle diese älteren Exemplare zur Altersgruppe V+ zusammengefasst werden mussten. Die Resultate der Altersgruppenbestimmungen sind in der folgenden Tabelle und in den Abb. 1 und 2 dargestellt.

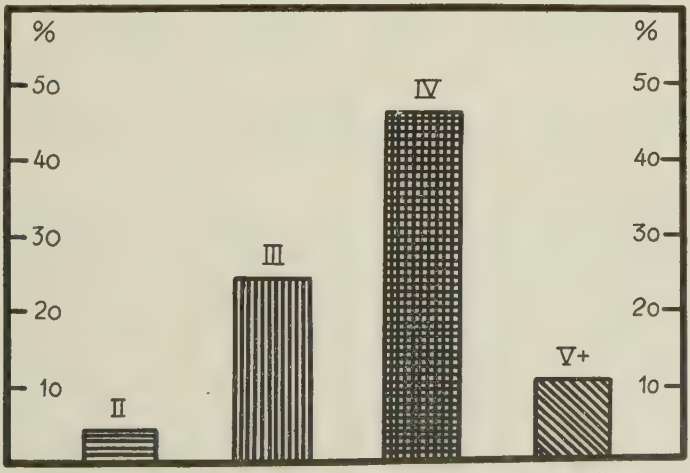
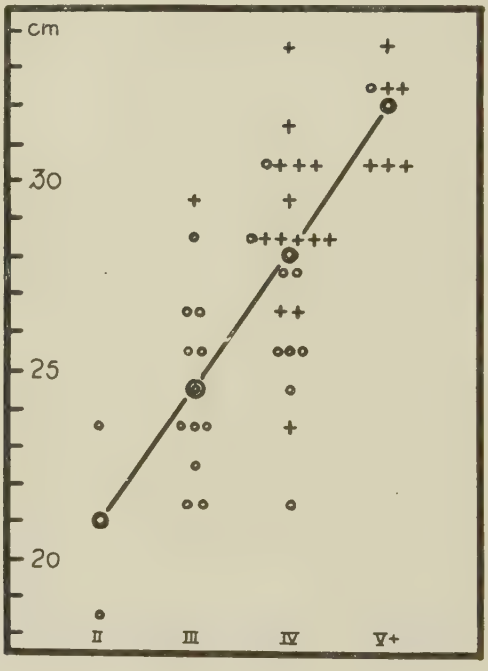


Abb. 1. Alterszusammensetzung der vor Liepāja gefangenen Schollen (1. Sept. 1933).

A. Gr.	II ♂	II ♀	III ♂	III ♀	IV ♂	IV ♀	V + ♂	V + ♀
Anzahl	2	0	11	2	9	14	1	6
Insgesamt	2 (4·4 %)		13 (28·9 %)		23 (51·1 %)		7 (15·6 %)	
Mittlere Länge cm.	21·6		24·7		27.9		31·8	
Mittleres Gewicht gm.	105		148		202		321	

Die im Vergleich mit den Angaben von K ä n d l e r (1934) recht erhebliche Grösse der vor Liepāja gefangenen Schollen erklärt sich durch die überaus geringe Besiedlungsdichte dieses Bestandes.



o = ♂♂
⊥ ♀♀
O = mittlere Länge

Abb. 2. Länge und Zuwachs der Schollen (Liepāja, 1. Sept. 1933).

3.

Die Ergebnisse der Wirbelzählung an 45 Exemplaren lassen sich zu folgender Korrelationstabelle der Rumpfwirbel- und Schwanzwirbelzahlen zusammenfassen (komplexe Wirbel = 1):

Vert. praeh.	Vert. haem. 28	29	30	31	32	n	M (V. haem.)
12	0	3	1	7	1	12	30·50
13	2	5	15	9	1	32	30·06
14	0	1	0	0	0	1	29·00
n	2	9	16	16	2	45	30·16
M (V. praeh.)	13·00	12·78	12·94	12·56	12·50	12·76	42·92

Es ergeben sich danach für die einzelnen Werte der Gesamtwirbelsumme (Vert. S.) folgende Frequenzen:

Vert. S.	41	42	43	44	45
n	5	6	23	10	1
%	11·1	13·3	51·1	22·2	2·2

Ein Vergleich der für die Wirbelzahl der ganzen Wirbelsäule (Vert. S.) und ihre beiden Abschnitte (Vert. praeh. und Vert. haem.) erhaltenen Werte mit den entsprechenden, von Kändler (1935) an 82 Laichschollen der südlichen Gotlandmulde im gleichen Jahr (1933) gefundenen, zeigt eine gute Übereinstimmung:

	Vert. praeh.	Vert. haem.	Vert. S.
Liepāja (Mannsfeld)	12·76	30·16	42·92
S. Gotlandmulde (Kändler) ..	12·80	30·20	43·00

Diese Übereinstimmung und die geographische Lage des Fangortes weisen darauf hin, dass die vor Liepāja gefangenen Schollen zur Laichgemeinschaft der Gotlandmulde gehören.

4.

Wie zu erwarten war, wurden auch bei den vor Liepāja gefangenen Schollen Wirbelanomalien festgestellt und zwar:

Wirbelverwachsungen bei 13 Exemplaren (28·9 %)
Komplexe Wirbel bei 19 Exemplaren (42·2 %)

Das Auftreten von komplexen Wirbeln wurde beobachtet:

am 1. Vert. praeh. (Vert. 1) ..... in 3 Fällen (6·7 %)
„ vorletzten Vert. haem. (Vert. n—1) ..... „ 15 „ (33·3 %)
„ letzten Vert. haem. = Urostyl (Vert. n) .. „ 3 „ (6·7 %)
„ Vert. 1 und am Vert. n—1 ..... „ 2 „ (4·4 %)

Auf die einzelnen Werte für Vert. S. verteilt sich das Vorkommen der Exemplare mit komplexen Wirbeln folgenderweise: (s. Abb. 3).

Vert. S.	41	42	43	44	45	n	M(Vert.S.)
normal	3	1	13	8	1	26	43·12
komplex	2	5	10	2	0	19	42·63
insgesamt	5	6	23	10	1	45	42·92
davon komplex % ..	66·5	83·3	43·5	20·0	0·0	42·2	

Kändler (1935) hat an einem grossen Schollenmaterial aus der "eigentlichen Ostsee" als entsprechende Mittelwerte für Vert. S. festgestellt:

normal — 43·10, komplex — 42·44, insgesamt — 42·79

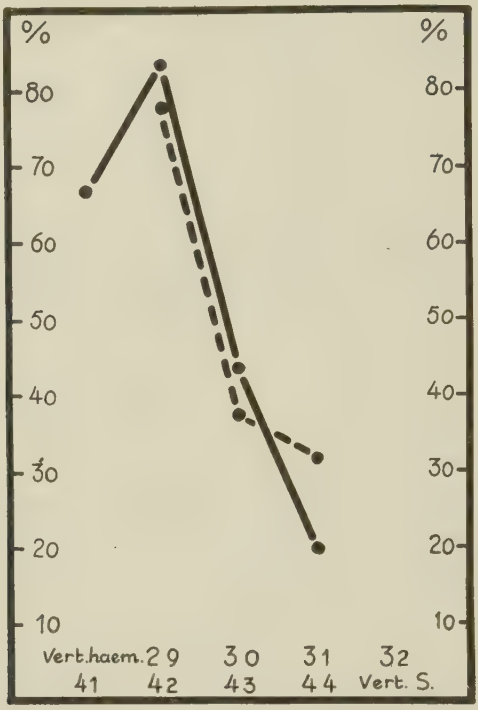


Abb. 3. Anteil der Individuen mit komplexen Wirbeln, bezogen auf Vert. S. (· — ·), und der Individuen mit komplexem Vert. n und Vert. (n-1), bezogen auf Vert. haem. (· - - - ·).

Komplexe Wirbel traten bei 47·8 % aller von K ä n d l e r aus diesem Gebiet untersuchten Exemplaren auf; in der südlichen Gotlandmulde allein bei 54 %.

Die am lettländischen Schollenmaterial festgestellten Werte für (Vert. S.) weisen somit — ähnlich wie bei der Scholle aus der Gotlandmulde — eine deutliche Erhöhung der Wirbelzahl gegenüber dem Durchschnittswert für die Schollen der "eigentlichen Ostsee" auf.

Die Anzahl der Proc. spin. beträgt für das ganze Material aus Liepāja im Durchschnitt 43·40. Aus den Angaben von K ä n d l e r lässt sich für die südl. Gotlandmulde dieser Wert 43·58 errechnen.

5.

An Flundern (*Pl. flesus*) stellte M a n n s f e l d (1934) fest, dass die Länge der komplexen vorletzten Wirbel, der Vert. (n—1), zwar grösser sei als diejenige der vorhergehenden Vert. (n—2); der Unterschied betrage jedoch nicht ein Drittel, wie K ä n d l e r (1932) für die Scholle annahm, sondern sei erheblich geringer: "Ich habe die Länge der Vertebra (n—2) und (n—1) bei den von mir untersuchten Flundern aus Windau gemessen und konnte feststellen, dass der Unterschied in der

Wirbellänge zwischen normalen Exemplaren und solchen mit acc. Proc. spin. bedeutend kleiner ist." Die entsprechenden Mittelwerte lauten:

	Vert. (n-1)	Vert. (n-2)	Vert. (n-3)
normal	3·52 mm.	3·59 mm.	3·83 mm.
m. acc. pr. spin.	4·03 „	3·79 „	3·86 „

Die Längen der Wirbel: Vert. (n—1), Vert. (n—2) und Vert. (n—3) wurden hierbei an je 25 Exemplaren mit normalem und komplexem Vert. (n—1) bei schwacher Vergrösserung mit dem Okularmikrometer gemessen und auf mm. umgerechnet.

Die oben genannten Werte zeigen, dass bei *Pl. flesus* von der lettländischen Ostseeküste (Ventspils) der vorletzte Wirbel — Vert. (n—1) — bei Exemplaren, wo derselbe komplex ausgebildet ist, um das 1·06-fache länger ist als der vorhergehende. Bei Exemplaren mit normalem Vert. (n—1) ist derselbe im Mittel kürzer als der Vert. (n—2).

Bei *Pl. platessa* aus Liepāja wurden entsprechende Messungen an 15 Skeletten, welche komplexe Vert. (n—1) zeigten, vorgenommen:

Vert. (n-1)	Vert. (n-2)	Vert. (n-3)
4·04	3·33	3·35 mm.
120·6	99·4	100·0 %

Die mittlere Länge der komplexen Vert. (n—1) betrug 121·3 % der mittleren Länge des vorhergehenden Vert. (n-2). Der Quotient ihrer Längen betrug somit 1·21.

K ä n d l e r (1935) hat ähnliche Messungen an "Nordseeschollen — 2—4 cm. grossen Exemplaren der 0-Gruppe" vorgenommen und dabei für das Längenverhältnis der beiden Wirbel den Wert 1·46 erhalten. Er sieht darin eine Stütze für seine Annahme, dass für die komplexen Wirbel der Zahlenwert rund 1·5 betrage. Die obigen an *ausgewachsenen* Flundern und Schollen gewonnenen, stark abweichenden Messungsergebnisse weisen jedoch darauf hin, dass die relative Wirbellänge des komplexen Vert. (n—1) eine inkonstante Grösse sein dürfte, die im Verlaufe der individuellen Entwicklung und des Ossifikationsprozesses starke, ausgleichende Veränderungen durchmacht. Sie kann damit kaum als Beweis für die erwähnte Annahme von K ä n d l e r gelten.

6.

Im Verlauf der Wirbelmessungen an den vor Ventspils (Windau) gefangenen Flundern stellte der Verfasser fest: "Es finden sich auch unter den normalen Exemplaren, ohne acc. Pr. spin., solche, deren vorletzter Wirbel länger ist als der vorhergehende, und zwar bei 48 % der Exemplare" (M a n n s f e l d, 1934).

Die Messungen der Wirbellängen dieser Exemplare hatten folgende Werte ergeben:

Vert. (n-1)	Vert. (n-2)	Vert. (n-3)
3·89	3·62	3·75 mm.
103·73	96·53	100·00 %

Der Quotient der Wirbellängen von Vert. (n—1) und Vert. (n—2) betrug 1·07.

Bei der Untersuchung der Jungschollen aus der Nordsee fiel es ebenfalls K ä n d l e r (1935) auf "dass der letzte Wirbel auch bei normaler Ausbildung gelegentlich abnorm lang ist." Im Ergebnis seiner Messungen erhielt er für die Exemplare mit normalem "letzten Wirbel", nach meiner Zählweise = Vert. (n—1), den Quotienten 1·17 (1·13 — 1·26) und stellte fest: "dieser ist vielmehr auch bei normaler Gestaltung in der Regel etwas *länger* als der vorletzte Wirbel."

Bei den untersuchten *Schollen* aus Liepāja wurden wiederum Messungen mit dem Okularmikrometer zur Feststellung der relativen Wirbellängen an 28 Exemplaren mit normalem Vert. (n—1) vorgenommen. Es erwies sich hierbei, dass bei 26 Exemplaren (93 %) der Vert. (n—1) länger war als der vorhergehende Wirbel, bei 1 Exemplar waren beide Wirbel gleich lang, bei 1 Exemplar war der Vert. (n—2) länger. Die Mittelwerte für alle 28 Exemplare betrugen:

Vert. (n-1)	Vert. (n-2)	Vert. (n-3)
3·87	3·36	3·55 mm.
109·01	94·65	100·00 %

Die mittlere relative Wirbellänge der Vert. (n—1) und Vert. (n—2) betrug 1·15 für sämtliche 28 Exemplare mit normalem Vert. (n—1) und 1·17 für die 26 Exemplare mit längerem Vert. (n—1).

Diese an ausgewachsenen Schollen erhaltenen Werte der relativen Wirbellänge stimmen sehr gut mit denjenigen von K ä n d l e r für die Jungschollen aus der Nordsee überein (relative Wirbellänge = 1·17). Um so auffallender erscheint der Unterschied, der in Bezug auf die relative Wirbellänge des komplexen Vert. (n—1) festzustellen ist:

	Vert. (n-1) normal	Vert. (n-1) komplex
K ä n d l e r	1·17	1·46
M a n n s f e l d	1·15 (1·17)	1·21

Sollte sich für ausgewachsene Schollen aus der Nordsee eine gleiche Abweichung gegenüber den Jungschollen beobachten lassen, so dürfte darin eine weitere Bekräftigung für die Annahme zu sehen sein, dass auch die komplexen Wirbel das Produkt sind "einer unterbliebenen Trennung zweier Wirbelanlagen" (M a n n s f e l d 1934, S. 98), dass "der vorletzte Wirbel sich in seiner Anlage nicht mehr von der vorhergehenden Anlage abtrennt und mit derselben in mehr oder weniger starkem Zusammenhang bleibt, wobei nun zwei Fälle eintreten können, entweder ist die Trennung der beiden Wirbelanlagen doch eingeleitet

worden, dann erhalten wir einen "komplexen Wirbel" mit acc. Proc. spin., oder es hat nur eine Streckung der Wirbelanlage stattgefunden, dann ergeben sich Exemplare, bei denen der Vert. (n—1) länger ist als der vorhergehende" (Mannsfeld 1934, S. 97). Ähnliches spricht Kändler (1935, S. 468) mit seiner Vermutung aus, "dass bei der Segmentation gelegentlich ein Mesenchymrest übrigbleibt, die Teilung also gewissermassen nicht 'aufgeht', und dieser Gewebeteil vermag nicht einen vollständigen Wirbel zu bilden, sondern nur ein Fragment, das bereits auf frühen Entwicklungsstadien in den letzten Wirbel einbezogen wird und ihm sein besonderes Gepräge gibt" und weiter (S. 470): "dass das Auftreten akzessorischer Dornfortsätze am letzten Wirbel durch eine unvollkommene Abgliederung der letzten Wirbelanlage vor dem Urostyl zu erklären ist."

7.

Es dürfte nunmehr kaum ein Zweifel darüber bestehen können, dass innerhalb der Ostsee bei den Schollen — ebenso wie bei den Flundern — eine *aktuelle* Reduktion der Wirbelzahl stattfindet.

Diese Reduktion ist beschränkt nur auf das kraniale und caudale Ende der Wirbelsäule.

Variations- und vererbungsstatistische Untersuchungen an Ratten und Menschen, die K. Kühne im Kaiser Wilhelm-Institut für Anthropologie in Berlin—Dahlem ausführte, haben ergeben: "Es vererbt sich lediglich die, wie einstweilen gesagt werden soll, 'Tendenz' der Wirbelsäule, kopfwärts oder steisswärts zu variieren .... dass die Einzelausgestaltung überzähliger Wirbel u. s. w. rein umweltbedingt ist." (Fischer 1936).

Dem widersprechen die von Johs. Schmidt bei seinen experimentellen Untersuchungen über Vererbung der Wirbelzahl bei *Zoarces viviparus* erzielten Ergebnisse nur scheinbar, denn wie auch Johnsen (1936) feststellt: "The environment of the eggs and young during development cannot necessarily be accepted as being identical with that of the fish itself." Die Untersuchungen von Schmidt über die Wirbelzahl bei *Anguilla anguilla* liefern demgegenüber den Beweis dafür, dass bei oviparen, in einem *einheitlichen* Gebiet laichenden Fischen keine Variation der Wirbelzahl festzustellen ist, obgleich die ausgewachsenen Individuen ausgesprochen eurytop sind und in Gewässern mit verschiedensten Umweltbedingungen leben. Die Variation der Wirbelzahl wird somit ausschliesslich bereits in den jüngsten Entwicklungsstadien bestimmt. Nach Johnsen (1935) sollen hierbei die Umweltfaktoren durch Beeinflussung sowohl der Eigrösse als auch des zeitlichen Ablaufes der Zellteilungsprozesse wirken.

Wir können für die Scholle der Ostsee eine — wohl erblich fixierte — *primäre* Wirbelzahl annehmen, die der mittleren Anzahl der Proc. spin., also etwa einer Wirbelsumme von 43·3 — 43·6, entsprechen dürfte. Diese wäre dann durch eine *sekundäre* Reduktion auf die heute bei den einzelnen Laichgemeinschaften beobachteten Werte der Wirbelzahl herabgemindert worden. Die hierbei bestehenden Beziehungen

zwischen den Umweltbedingungen — insbesondere der Temperatur, dem Salzgehalt und damit der Dichte des Meerwassers — in den Laichgebieten und der Variation der Anzahl ausgebildeter Wirbel dürften sich aber wohl kaum als mathematische Funktion darstellen lassen.

Es lässt sich auch schwerlich eine Übereinstimmung mit den Überlegungen von Johnsen (1936) über das "Fjord-Phänomen" herstellen, wenn wir die Befunde über die Anzahl der Wirbel und die Tendenz ihrer Variabilität bei den Schollen der Ostsee historisch verstehen wollen. Die primäre grössere Wirbelzahl der Ostseescholle dürfte den höheren Salzgehalten und Temperaturen des Baltischen Meeres während der Einwanderungsperiode der Scholle, also zur Litorinazeit, entsprechen. Die heute bei den einzelnen Laichgemeinschaften zu beobachtenden, durch eine sekundäre Reduktion entstandenen niedrigeren Wirbelsummen müssten dagegen den geringeren Mittelwerten dieser Umweltfaktoren in den zugehörigen Laichgebieten der heutigen Ostsee entsprechend ausgebildet worden sein.

Diese Überlegungen ergeben somit einen gewissen Widerspruch zu den generalisierenden Folgerungen von Johnsen. Es weist jedoch auch Schnakenbeck in seiner Besprechung der Arbeit von Johnsen — *Journal du Conseil*, 1936 (379—381) — darauf hin, dass einem geringeren Salzgehalt "im allgemeinen eine geringere Wirbelzahl" entspricht.

Die Beobachtungen von Kändler (1935) zeigen auch in Bezug auf die Analflossen "dass die Variabilität der Strahlenzahl von den örtlichen Verhältnissen beeinflusst wird, wodurch eine gleitende Verschiebung des Mittelwertes bewirkt wird."

Mit diesen Erscheinungen der Veränderlichkeit wesentlicher Eigenschaften bei der Scholle läge gleichzeitig ein Fall vor, der den Anschauungen von Rensch über umweltbedingte, gerichtete geographische Variation entspräche. Es erscheint jedoch keinesfalls als sicher, dass die beobachteten Unterschiede der Wirbelzahl und des Auftretens von "Anomalien" im Rahmen der für die Gesamtart charakteristischen Variationsbreite tatsächlich *erblich* fixierte Merkmale der einzelnen Laichgemeinschaften darstellen, oder ob sie nicht vielmehr in jeder Generation während der individuellen embryonalen Entwicklung neu erworben werden.

Solange die erbliche Fixierung der bisher als "Rassenmerkmale" herangezogenen Eigenschaften und deren Variabilität nicht erwiesen ist, können wir bei der Scholle nur mit Einschränkung von einer Bildung geographischer *Rassen* sprechen. Das Vorkommen einer *geographischen Variation* bei der Scholle, wenngleich dieselbe auch noch nicht zu einer Bildung erblicher Rassen geführt haben mag, dürfte dagegen als gesichert gelten.

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The Season in which "Winter" Zones in the Scales of Trout from Southern Norway are formed.

By

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DURING our holidays we have for many years fished for trout in the southern part of Norway. As we wanted to learn something about the fish we caught, we measured the fish, secured scale samples, and made notes as to the quality or "condition" of the fish, the development of the reproductive organs, etc.

When dealing with the scales, however, in order to obtain information as to the age and growth of the trout from the different waters, we met certain difficulties. The theory of scale reading is based upon the assumption that the zones of narrow growth-elements in the scales are formed during the winter; hence the term "winter" zones. In some lakelets we found scales with narrow growth-elements close to the edge of the scale during the summer, and some months later in the autumn the scales from the same waters appeared to have broad growth-elements near the edge. In other localities the formation of the zone seemed to be in conformity with the ordinary theory.

On earlier occasions one of us has dealt with the scales of the cod[1]) and pollack[2]) from the Skagerak and the scales of the young salmon[3]) living in the rivers. In the case of the young salmon the zone, or check, was finished in late summer. The same occurred regularly in the cod. But the scales of the pollack had true "winter" zones.

As there now seemed to be some variation as to the season in

1) Dannevig, Alf: "On the Age and Growth of the Cod (*Gadus callarias* L.) from the Norwegian Skagerrack Coast." Bergen 1933.
2) Dannevig, Alf and Sørensen, Adolf:"On the Age and Growth of the Pollack (*Gadus pollachius* L.) from the Norwegian Skagerrack Coast." Bergen 1933.
3) Dannevig, Alf: "Om dannelsen av årringer i lakseungenes skjell." Norsk Jæger og Fiskerforenings tidsskrift, hefte 5, Oslo 1928.

which the "winter" zone was formed in the trout scales, in 1933 we therefore collected some scale samples in different seasons from a few of the localities that we had fished before. We hoped in this way to throw some light on the problem. The collecting of the material, the measurements of the scales, etc. was made possible by grants from the fund of Professor R. Collett.

As the result of the examination may be of some interest to scale readers in general, we may refer to the conclusion arrived at. We will, however, only deal with the problem as far as the season of the formation of the zones is concerned. The question of the causes of the differences found will be dealt with later, when more data have been collected bearing directly upon that problem.

Our data are gathered from Lindåstjern, Mjåvatn, Ufsvatn, and Holmevatn. The three localities first mentioned are situated in the wooded district about 30—40 km. from the coast, and at a height of approximately 160—210 m. above sea level. The waters here are all regulated, but to a very small degree. The water level is kept 1—2 m. higher during spring than during the rest of the year, when it is governed by the downfall. The last locality, the Holmevatn, lies in the mountains near the upper tree-limit, approximately 600 m. above sea level.

The water in the districts considered is mildly acid. The pH varies ordinarily between 5·5 and 6·0. The ice covering is thick during winter and lasts for about half a year. In the mountains only four months may be free from ice, namely, June to September.

The scale samples were taken near the middle line of the fish just in front of the adipose fin. When cleaned, the scales were mounted on object glasses in albumen-glycerin and examined in the Edinger projection apparatus. On the assumption that the growth of the scale is nearly proportional to the growth of the fish, the length of the fish corresponding to each completed zone in the scale was calculated in the ordinary way. The width of the margin of the scale, measured from the nearest completed zone, was recorded in centimetres corresponding to the growth of the fish. Special attention was paid to the character of the outer part of the scale. The following terms were used. *Completed zone* when the check formed by the beginning of new growth could be ascertained. When the new growth could be measured, the margin was put down with *open elements* of growth. When the elements became narrow, like the elements in the last completed zone, the margin was called *narrow*. There is, of course, no definite limit between these three groups. The classification is — as is the interpretation of the scales — dependent upon personal judgement.

The results concerning the age and growth of the trout will be given in detail in a paper in Norwegian, this point being of more local interest. In this paper we give a table showing the length increment of the fish corresponding to each zone in the scale for the most common age-groups — three and four years of age. We have found those values more convenient than l_1, l_2, l_3, l_4 ....

Table 1.

The length increment for each zone.

		Number examined.	I	II	III	IV
Lindåstjern	1933	75	5·6	7·6	7·9	5·1
Mjåvatn	1933	66	4·3	5·7	7·4	7·5
Ufsvatn	1933	34	4·1	5·5	6·9	5·5
Holmevatn	1928 1929	53	5·9	8·8	7·7	7·2

The Lindåstjern in Mykland has an area of 0·1 km^2. It is situated in a somewhat barren, thinly wooded district, and a small stream passes through the lake. In summer, when the water is low, the lake is divided into two parts, and is then rather shallow. The trout spawns in the stream running into the upper part of the lake, but when the water here dries out in the summer, the young trout is evidently forced to go into the lake at a very young age. It spawns also in the narrow waters between the two parts. Table 2 gives the number of fish examined, and the character of the scale margin.

Table 2.

Lindåstjern.

Date	Number of fish examined	Number of zones in the scales	Length of the fish	Character and average relative width of the scale margin: Open elements		Narrow elements		Completed zone	Average width of the scale margin
1933			cm.	number	cm.	number	cm.	number	cm.
$^{12}/_{4}$	10	2—6	24—30	3	1·7	5	4·1	2	2·6
$^{3}/_{6}$	24	2—4	18—31	9	1·4	13	4·5	2	3·0
$^{13-16}/_{8}$	38	3—5	18—33	19	1·6	9	3·9	10	1·7
$^{15-16}/_{10}$	11	3—4	23—28	8	1·9	0		3	1·4

In April two specimens had a completed zone near the edge of the scale. Three had a margin of open growth-elements corresponding to a growth of 1—2 cm. of the fish. Five individuals had narrow growth-elements near the edge. The widths of the margins in these five corresponded to a growth increment of 3·5—5 cm. of the fish — or approximately the length increment in ¾ of a year, according to Table 1. In June two specimens had a completed zone near the edge of the scale. Nine had a narrow margin with open growth-elements. The rest, thirteen specimens, had very broad margins; the growth-elements at the edge of the scale had here become narrow. In August ten specimens had just finished the zone. Nineteen had finished it a short time before and had a narrow margin of open growth-elements at the edge of the scale. Nine fish were about to form the zone. They had a broad margin and narrow growth-elements at the edge of the scale. In October three specimens had just finished the zone. Eight had a margin of open growth-elements. It is evident that most of the fish in Lindåstjern form zones of narrow elements during summer.

Fig. 1. Scales of trout from Lindåstjern.

a. J. No. 35 a. 12-IV-1933. L = 28 cm. Three completed zones. The margin with relatively widely separated ridges followed by narrower elements of growth.

b. J. Nr. 144 a. 3-VI-1933. L = 21 cm. Three completed zones. The last close to the margin.

c. J. No. 323 a. 13-VIII-1933. L = 25·5 cm. Three completed zones. The last close to the margin, with one or two wide ridges outside.

d. J. No. 753 a. 15.-X.-1933. L = 28 cm. Three completed zones. The last one at a short distance from the margin.

Looking at the values which give the average width of the margin for all categories together we see that there is a maximum in June and a minimum in October. We should expect the average width of the margin to be smallest when the majority of the fish have just finished the zone, and to be greatest just before the zones are finished. These measurements, therefore, confirm the results arrived at by the subjective inspection of the character of the scale margin. The photographs, Fig. 1, a—d, illustrate the normal character of the scales from this lakelet.

We now turn to Mjåvatn, a lake situated only a few hundred metres from the Lindåstjern. The biological conditions are quite different, however; the lake is much bigger, approximately 2·2 km.^{2} in area and relatively long and narrow. A small river, the Risdalselv, passes through it. The trout spawns in the lake, in the river upstream, and also in several smaller streams. In contrast with the former locality, we may therefore expect to find here trout of diverse origins. Turning to the data we find the following:

Table 3.

Mjåvatn.

Date	Number of fish examined	Number of zones in the scales	Length of the fish	Character and average relative width of the scale margin: Open elements		Narrow elements		Completed zone	Average width of the scale margin
1933			cm.	number	cm.	number	cm.	number	cm.
$^{12}/_{4}$	18	3—6	22—35	2	2·3	6	3·7	10	1·5
$^{3-4}/_{6}$	46	3—6	21—30	27	2·1	10	6·2	9	2·6
$^{13-16}/_{8}$	15	3—5	22—32	2	1·5	10	5·2	3	3·7
$^{16}/_{10}$	7	3—5	24—29	2	2·3	4	5·5	1	3·8

On 12th April we found a number of trout which had just finished zones, or they had already formed a few open ridges outside. But there were also some scales with narrow growth-elements near the edge. In June the margin of the scales with narrow elements was considerably broader. Some specimens had a completed zone, but most of them had open elements near the edge of the scale. In August most of the scales had a broad margin and narrow elements at the edge; a few had just finished zones, but some still had open growth-elements. In October we find the same, the zones being only a little broader.

The average width of the margin has its smallest value in April and its greatest value in October. In this locality apparently many trout finish their zones late in the year or during winter, but some during summer, for scales with a completed zone at the edge occur in all four samples.

In Ufsvatn, 0·35 km.^{2}, in Vegårdshei, we have an intermediate type of water. A small river passes through the water.

Table 4.
Ufsvatn.

Date	Number of fish examined	Number of zones in the scales	Length of the fish	Character and average relative width of the scale margin: Open elements		Narrow elements		Completed zone	Average width of the scale margin
1933			cm.	number	cm.	number	cm.	number	cm.
$10-12/4$	21	4—9	21—32	19	1·3	2	4·0	0	1·6
$13/6$	17	2—7	14—25	15	1·8	1	2·0	1	1·7
$2-4/8$	13	3—6	14—28	6	2·1	7	4·4	0	3·3
$21/9$	27	3—6	19—29	5	2·3	22	3·3	0	3·1

In April nearly all the trout have open growth-elements at the edge of the scale. In June the margin with open elements is a little broader. The values found in August show a further development of the zone. In September most of the scales have narrow elements near the edge of the scale. In this locality it seems that most of the trout lay down narrow growth-elements in the autumn. The values giving the average width of the margin show the same tendency.

As a last example we will give figures from a lakelet, Holmevatn, in the mountains between Tovdal and Bygland. The water is so acid that the trout cannot propagate here. The artificially hatched fry will, however, ordinarily survive when put out in the small lakes.

In the years 1925 and 1927 a few hundred fry were liberated, and during the grouse-shooting season (September) in 1928, 1929, and 1930 we succeeded in getting some fine trout. The details are given in Table 5.

Table 5.
Holmevatn.

Date	Number of fish examined	Number of zones in the scales	Length of the fish	Character and relative width of the scale margin: Open elements		Narrow elements		Completed zone
			cm.	number	cm.	number	cm.	number
1928 $5-11/9$	40	3	23—34	0		40	6·8	0
1929 $5-10/9$	12	4	29—38	2	3·5	10	5·0	0
1930 $4-9/9$	15	3	24—34	0		15	5·7	0
1930 $12/9$	2	5	34—40	0		2	3·0	0

The scales from this locality were extraordinarily homogeneous. They all show that the narrow growth-elements are formed in late summer. The finishing check, however, was not formed at the time of fishing. Looking at the growth increment for a full zone in Table 1, it is reasonable to assume that the zone will be completed within a short time.

These samples tend to show that the term "winter" zone ought to be abandoned when speaking of the zones of the trout scales. They ought to be referred to simply as zones, and the season when they are formed must be ascertained in some way or other for each locality. This is of special importance when dealing with the calculated length of the fish corresponding to each zone in the scale. If the zones in one locality are formed during summer, in another during winter, a comparison between the length attained at the different zones is of little value. Also, as regards determination of the age of the fish, it is helpful to make an analysis of the margin before estimating the age, especially when dealing with fish caught in the autumn. If this is not done, trout of the same age may be put in different year-classes. The general opinion that the narrow ridges are formed during autumn and winter as a result of low temperatures does not hold good.

In "The Interpretation of the Zones on Scales of Salmon, Sea Trout and Brown Trout" (Rapp. et Proc.-Verb., Vol. XCVII), page 9, T. H. Järvi and W. J. M. Menzies write: "The growth and appearance of sea trout scales varies so enormously from district to district and the abnormalities may similarly vary to the same extent that in the case of this species it is necessary that a scale reader should approach a new district with caution and should check his readings by means of marked fish or through a very careful study of an adequate number of samples taken over an extended period before he makes any definite pronouncement of his findings." Those words apply also to the brown trout in the southern part of Norway.

Reviews.

A. Defant. "Schichtung und Zirkulation des Atlantischen Ozeans. III. Lieferung. Die Troposphäre." Wiss. Ergebn. Deutsch. Atlant. Exped. a. d. Forsch.- und Vermessungsschiff "Meteor" 1925—1927. Bd. VI, Teil I, S. 289—411, Abb. 49—76, Beilage XXXVI—LIV a. Berlin und Leipzig, 1936.

This paper treats for the most part descriptively the structure of the troposphere layer of the Atlantic oceans. As defined by Defant and his associates this layer includes all oceanic water warmer than 8° C. Wüst has published a similar comprehensive examination of the colder, deeper, stratosphere layer and the two papers (comprising Volume VI, Part I, of the "Meteor" reports) are closely related, both because of the scheme of subdividing the voluminous material and also in their methods of presentation and arrangements. In these two studies the whole water-mass of both halves of the Atlantic are for the first time treated by modern methods as one unit.

Defant first analyses the observations from 717 reliable stations scattered over the whole area between 45° N. and 45° S. For these stations he has constructed depth curves (down to the lower limit of the troposphere) for temperature, salinity, and density (σ_t). He has recorded in a 44-page table the depths and mean values of the several subdivisions of the troposphere and the intensity of the vertical gradients separating them. Thus for each station, among other factors, the following have been determined:

The average value observed and the mean thickness of the relatively homogeneous surface layer;

The depth and intensity of the maximum gradient in the boundary layer;

The lower limit of this stable zone;

The existence of a salinity maximum wherever it occurs in the troposphere layer.

To demonstrate the importance of these factors and their significance in terms of circulation a large number (28 text figures and 21 coloured plates) of instructive diagrams have been constructed showing in horizontal and vertical projection the internal structure of the warmer waters of the whole Atlantic.

It might seem at first glance that seasonal and annual variations near the surface would somewhat detract from such a large-scale combination of observations. However, it must be borne in mind that the troposphere layer under the author's definition is limited on the north and south by the subarctic and subantarctic convergences. Thus a relatively small part of the area under consideration is influenced by a marked seasonal cycle. Moreover, the internal structure of the troposphere layer becomes more complex in the

tropics and subtropics, so that in the regions for which this study is of greatest significance the variations are at a minimum.

Even a superficial examination of the many excellent diagrams discloses at once that frequently in the past the observational material has been quite inadequate to show up the very sharp and complex stratification present in tropical waters at depths of less than 200 metres. Because in general the water-bottles have not often been spaced at sufficiently close intervals, the observations from individual expeditions have given little indication of the complicated pattern that D e f a n t's masterful analysis at once brings out. In particular, the author has charted the areas having a salinity maximum just below the surface layer and from this one standpoint has amassed overwhelming evidence that in both the northern and southern Equatorial Current there is an equatorward transfer of saline water at depths between 80 and 120 metres. Even in the belt occupied by the Equatorial Counter-Current, saline subsurface water is drawn in from each side. The author again points out that the position and internal structure of this important current is closely connected with the fact that the heat equator and the geographical equator do not coincide.

After a rather short discussion of the circulation of the troposphere layer in relation to the vertical changes in oxygen content and the distribution of plankton, which are topics more fully dealt with in other volumes of the "Meteor" reports, the author proceeds to present his data in vertical section. Temperature, salinity, and density are described for each of the "Meteor" profiles, and then for a north-south section in mid-ocean. Finally the same factors are plotted along the axis of the Equatorial Counter-Current, along both the northern and the southern subsurface movements which transfer saline water downward and away from the belts of maximum surface salinity, and also along the axis of the southern Equatorial Current where it is flowing north of the equator.

It is impossible here to touch on even a small percentage of the important new findings encountered in a paper of this scope. It is hoped that we have indicated that D e f a n t has again added to his already long list of fundamental investigations in physical oceanography.

For readers who are not familiar with the present-day major technical problems that beset the investigator who seeks to work out the directions and relative velocities of subsurface oceanic currents, a word of caution may be added. This new paper by D e f a n t, as well as the other "Meteor" reports, assumes at the outset that the boundary between the ocean troposphere and stratosphere, which by definition follows the axis of the oxygen minimum layer, can for this reason be considered as a layer of minimum motion. In other words, D e f a n t and his associates believe that the lower limits of the Equatorial Currents are slanting ones, increasing in depth poleward from about 200 metres in low latitudes to about 600 metres in the horse latitude belts. They have brought forward considerable evidence to support this point of view. Nevertheless, their evidence is largely indirect, and while this is not an appropriate place to discuss this important controversial point, the reviewer believes that a good case can still be made for the older theory that the major oceanic currents continue to roughly parallel the surface movements down to at least 2,000 metres. If the latter standpoint should finally be proven correct and the layer of oxygen minimum is really following the surface drift, though at a much slower rate, it would become necessary to modify the relative velocities and motions which some of D e f a n t's diagrams show for the superficial layers within the latitudes of the trade winds.

C. O'D. I.

A. Defant. "Quantitative Untersuchungen zur Statik und Dynamik des Atlantischen Ozeans. II. Lieferung. Ausbreitungs- und Vermischungsvorgänge im Antarktischen Bodenstrom und im Subantarktischen Zwischenwasser." Wiss. Ergebn. Deutsch. Atlant. Exped. a. d. Forsch.- und Vermessungsschiff "Meteor" 1925—1927. Bd. VI, Teil II, S. 55—96. Berlin und Leipzig, 1936.

The thermohaline structure of the oceanic stratosphere can safely be regarded as the result of equilibrium between advective currents and mixing processes, and Professor Defant uses the vertical sections constructed by G. Wüst as the basis of a quantitative study of the antarctic bottom current and sub-antarctic intermediate current.

Each advective movement is regarded as a "free turbulent current" in which consecutive cross-sections are influenced by similar mixing processes, and the conditions specially considered are those in which a distinctive water mass spreads forwards between two others that are stationary or moving with constant velocities. For such a system an expression is derived giving the ratio of eddy-conductivity *(Austausch)* A to velocity u in terms of a particular common property s and the inclination of the current.

The vertical sections follow the main directions of flow in the western half of the Atlantic, and A/u has been evaluated step by step for elements 500 km. long and 250 m. deep between 41° S. and 26° N. in the bottom current, and for 500 km. × 100 m. elements between 42° S. and 11° N. in the intermediate current. The only uncertainty which arises in the calculation is in the assignment of values to m, the height through which the current rises or falls in each element, but it was found that a choice could be made without much difficulty if a number of values of A/u were calculated for slightly different values of m and compared with similar values obtained for neighbouring elements; the range of possible values is small, since the main trend of the current is shown by the isotherms and isohalines.

The temperature and salinity distributions gave approximately the same results, and average values have been used for constructing vertical sections. Positive values of A/u indicate northward movement, and negative values southward movement; the inclination of the directional arrows, based on the values of m, shows the rise or dip of the current.

In the bottom current the values of A/u depend to some extent on the topography of the sea-floor, falling to 2 and 3 over the ridges, where the speed of the current is likely to be greater and mixing less, and increasing to 5 and 6 in the deep basins. Assuming $A = 4$ cm.$^{-1}$ g. sec.$^{-1}$ (the value suggested by Wattenberg as a result of his work on the distribution of calcium in the bottom layer and its rate of solution from the deep-sea sediment) the possible velocities for the bottom current are 1·5 to 2 cm./sec. over the ridges and 0·5 to 1 cm./sec. in the basins. The section constructed gives a clear indication of the boundary between the northward movement in the bottom current and the southward movement in the lower stratum of the overlying North Atlantic deep water. Possible velocities for the southward movement are 0·3 to 0·8 cm./sec.

The section along the intermediate current shows that the velocity is greatest at the level of minimum salinity, and it confirms Wüst's conclusion that the boundary between that current and the underlying North Atlantic deep water is marked by a low oxygen content.

A further examination of the rate of increase of the salinity of the intermediate current towards the north between 42° S. and 10° N. shows a linear increase (within limits of error $\pm 0{\cdot}02\ ^0/_{00}$) as far as 12° S.; at this point there is a sudden decrease of $0{\cdot}05\ ^0/_{00}$ and then a continued linear

increase as far as 10° N. Professor Defant believes the break in the linear increase to be due to a disturbance *(Störung)* moving northwards from the region of origin of the current, and although he expresses himself with great caution, entertains the possibility that it has been formed in the same way as another rudimentary disturbance in 39°S., having travelled the intervening distance in one year at the rate of 12 cm./sec.

Professor Defant regards 12 cm./sec. as a likely velocity, but emphasizes that the existence of two disturbances linked by such a plausible velocity assumption is probably accidental. Here, perhaps, greater emphasis should have been given to the fact that the "Meteor" data are not suitable for the examination of transitory variations in a longitudinal section, and it is just possible that the break in the salinity gradient is a misrepresentation of the actual conditions brought about by combining observations made over a rather long period; in this particular instance the "Meteor" stations north of the break were made 3 months later than those south of it, and the observations between 20° S. and the equator were, in all, spread over a period of 8 months.

No absolute values can be obtained for A or u, but the question arises whether it is correct to assume that A is larger in the more stable layering of the intermediate current than it is in the bottom current; using $A = 4$ cm.$^{-1}$ g. sec.$^{-1}$ and the average value $A/u = 0{\cdot}82$ from Table 10, one obtains a velocity of only 5 cm./sec.

In the final sections of the report there is further theoretical treatment of currents of the same type as the intermediate current, and another method is evolved for the calculation of A/u using the $s = f(t)$ relation. The way in which periodic disturbances may be propagated is also closely studied and it is emphasized that the existing data are too scanty to provide reliable information.

G. E. R. Deacon.

C.-G. Rossby. "Dynamics of Steady Ocean Currents in the light of Experimental Fluid Mechanics." Pap. in Phys. Oceanogr. and Meteor. Vol. V, No. 1, pp. 1—43, 26 Figs., 2 Charts. Cambridge, Mass., 1936.

Aware of the numerous limiting presuppositions on which the former theories on dynamical oceanography are based, Rossby in this paper regards the problems from a new point of view. Beside the well-known forces controlling the movements of the water, namely, the horizontal pressure-gradient, the deflecting force, and the frictional force resulting from the relative motion of superimposed strata, he introduces the frictional force resulting from large-scale horizontal mixing.

The mathematical theory of a current produced by discharging water into a basin through a jet, was given in 1926 by Tollmien. The two-dimensional case has been studied experimentally by Förthmann and recently, on Rossby's suggestion, by Peters and Bicknell. It is found that the total transport of momentum is approximately the same at different distances from the jet, while the mass transport increases downstream; thus the current is divergent, drawing in water from the surroundings. Conditions must be similar also in a steady deep current, flowing through an ocean basin of uniform depth.

In a stratified medium the system becomes too complicated for a detailed mathematical discussion. Qualitatively it is, however, possible to deduce that the internal boundary between the stratum of the current (the troposphere) and the stratum below (the stratosphere) must dip down towards the right. If the inflow of water be equally great from both sides, the rate of inflow

must be greater on the left side than on the right, because on the left side it is restricted to a relatively narrow layer, while on the right side it is spread out over a great depth. The internal boundary between the two water strata will be found at different depths at the edges of the wake stream and in the undisturbed water at some distance; the water columns entering the wake stream must, therefore, undergo deformations, and these will produce vorticity in the surrounding water. It is found that compensation movements are set up in the surroundings of the wake stream; these movements have a component in the direction of the current itself on the right side of the wake stream, while they appear as a counter-current on the left side. Such counter-currents are known along the left edges of the Equatorial Current and the Gulf Stream.

A result of the investigation is that the effect of lateral stresses acting in the direction of the motion must be to produce certain characteristic transverse velocity profiles. No general characteristics of this kind can be deduced from the former theories. If the actual conditions in the sea, as presented by observations, agree on the picture resulting from the theory, it will, therefore, be a valuable support of the whole view. In that case the associated mass (solenoid) distribution in a transverse plane must reasonably be regarded as a result rather than as a cause of the motion.

The second part of the paper contains a number of examples of the conditions in the Gulf Stream area near the American coast, taken from the observations of the "Atlantis." On the whole the temperature-salinity and oxygen-salinity diagrams exhibited seem to bring support to the theory.

The views of Rossby are new, but his theory is far from being complete. However, the general results obtained seem to bring a working hypothesis of high value, and continued work along this line may bring results of great importance in oceanography and meteorology.

Håkon Mosby.

C.-G. Rossby; R. B. Montgomery. "On the Momentum Transfer at the Sea Surface." I: "On the Frictional Force between Air and Water and on the Occurrence of a Laminar Boundary Layer next to the Surface of the Sea" by C.-G. Rossby; pp. 3—20, 4 Figs. II: "Measurements of Vertical Gradient of Wind over Water" by R. B. Montgomery; pp. 21—22, 1 Fig. III: "Transport of Surface Water due to the Wind System over the North Atlantic" by R. B. Montgomery; pp. 23—30, 1 Fig. Pap. in Phys. Oceanogr. and Meteor. Vol. IV, No. 3. Cambridge, Mass., 1936.

The interaction between the ocean and the atmosphere involves a number of difficult but important problems. With previous theoretical investigations as basis, Rossby in Section I of the present paper attempts to apply the theory to the available observational data.

In the case of a laminar sub-boundary layer existing next to the surface of the sea, one may expect the vertical distribution of wind above this layer to obey the general law established by von Kármán for flow over smooth plates. Observations with small wind-velocities and calm sea, such as those given by Montgomery in Section II of the same paper, are found to agree well on this law, and the assumption of a laminar sub-boundary layer thus appears reasonable.

Measurements over land have shown that the wind force usually increases proportionally to the logarithm of the height. Observations by Wüst in the Baltic show a vertical velocity distribution differing from the logarithmic law, giving a marked increase in the slope at 1 m. height. The observations

from the lower levels are in good agreement with von Kármán's law, while those from 1 up to 6 m. seem to correspond to a flow over a rough surface, the roughness parameter being about 0·6 cm. The increase in the slope at 1 m. may be explained as follows: —

The horizontal eddy shearing stress at some height above the wave tops must balance the horizontal components of all the forces acting on the air at the surface of the water. These forces consist of true shearing stresses and of the horizontal components of the normal pressures between the air and the water. If the waves are smooth, the horizontal components must be small and the observations will obey von Kármán's law. With stronger wind, the pressure distribution on the sea surface will probably become asymmetric; the normal pressures now have horizontal components which add to the true shearing stress. In this case von Kármán's law applies only to the layer in the immediate vicinity of the water.

The roughness parameter of the sea surface may also be determined from the angle between surface wind and gradient wind, or from the ratio between surface wind speed and gradient wind speed. And it may be determined from observations such as those formerly used by Ekman for determination of the surface shearing stress from storage of water by the wind. Determinations made according to these different methods are given; they all agree on an average roughness parameter of 0·6 cm.

In spite of partly conflicting results obtained by studying the rather scanty observational data, our knowledge of the frictional force between sea and air has increased considerably through Rossby's investigations. It is to be hoped that a more complete collection of observations will soon be made.

Section III is an application of results obtained in Section I and in previous investigations. Montgomery computes the surface winds over the North Atlantic from the mean pressure field for July, hence the transport of surface water at the centre of each five-degree square, and finally the convergence of drift current in cm. per day. The maximum region (15—20 cm. per day) lies between 40° W. and the West Indies, within a few degrees of 17½° N., the values decreasing regularly towards north and east. Near the African coast the convergence is negative, reaching — 34 cm. per day. The results are expected to be discussed more closely later.

Håkon Mosby.

W. Werenskiold. "Coastal Currents." Geofysiske Publ. Vol. X, No. 13. Oslo, 1935.

Die Abhandlung enthält eine praktische Vereinfachung der Methode, mit der man aus dem Massenfeld in einem vertikalen ozeanographischen Schnitt die Stromgeschwindigkeitsverteilung senkrecht darauf ermitteln kann. Man benötigt dabei nichts anderes als die Neigung der Isosteren bezw. Isopyknen in den verschiedenen Schichten, die man den graphischen Darstellungen mit genügender Genauigkeit entnehmen kann. Die Durchführung der Rechnung ist dadurch besonders einfach und elementar geworden. In ähnlicher Weise kann in Erweiterung der Methode mit einem Minimum von Rechenarbeit auch der Wassertransport von Küstenströmungen ermittelt werden. Die Methode wird praktisch an mehreren Beispielen erläutert und scheint tatsächlich die grosse Rechenarbeit der genauen Methode etwas abzukürzen.

A. D.

Ed. le Danois. "Observations hydrologiques des quatre premières croisières du navire 'Président Théodore Tissier'." Rev. Trav. Office des Pêches Marit. T. IX, Fasc. 2, p. 133—250, 66 Figs. Paris, 1936.

Ce fascicule contient l'exposé des travaux hydrologiques effectuées par le nouveau navire océanographique français, depuis le mois de novembre 1933 jusqu'au mois de juillet 1935. Il constitue en même temps le premier d'une nouvelle série que l'auteur se propose de publier selon le même plan général. Ce volume comprend les résultats des quatre premières croisières, à savoir: —

La première depuis le 24 novembre 1933 jusqu'au 3 janvier 1934, en parcourant le Golfe de Gascogne, la côte ouest de la Péninsule Ibérique, la région comprise entre le Portugal, Madère et les Canaries et la région au large du Maroc, s'étend donc entre les latitudes de 28° et 48° N. Quarante-trois stations ont été faites, avec 134 prises d'échantillons d'eau et détermination de température à des profondeurs comprises généralement entre 10 et 200 mètres, quelquefois aussi jusqu'à 500 et 1000.

La deuxième croisière, du 10 mai au 3 juillet 1934, commença à Brest et, après des observations en Mer Celtique (désignation très heureuse proposé par l'auteur pour "la région placée au Sud-Ouest des Iles Britanniques et à l'Ouest de l'entrée de la Manche et qui est limitée par le Sud de la côte d'Irlande, la mer d'Irlande, le Canal de Bristol, la Cornouaille anglaise, la Manche, et l'Armorique. Du coté du large, la Mer Celtique prend fin à la bordure du plateau continental") et en Manche, et d'un voyage à Copenhague, s'est poursuivie à travers la Mer du Nord, depuis le Skagerak jusqu'aux Iles Shetland, puis à l'Ouest de l'Irlande pour revenir enfin en Mer Celtique et terminer à Brest. Dans son ensemble, cette croisière comprend 79 stations avec 240 observations de salinité et de température.

La troisième croisière, la plus longue des quatre qui sont rapportées, dura du 1 septembre au 7 novembre 1934; en plus de deux grandes sections transatlantiques, la première, entre Brest et Halifax (Nouvelle Ecosse) suivant presque toujours le parallèle de 45° N., du 1er au 17 septembre, avec 65 stations et 283 observations entre 10 et 2000 m.; la deuxième, entre Saint Jean de Terre Neuve, Faial (Açores) et Lorient, du 21 octobre au 6 novembre, avec 47 stations et presque 200 observations a encore plus particulièrement parcouru la région des Bancs de Terre Neuve et le Golfe du Saint Laurent (66 stations).

La quatrième et dernière croisière a été effectuée en 1935, du 8 mai au 15 juillet et comprend un ensemble de 122 stations (avec 400 observations environ) en Mer Celtique et au large des côtes françaises et espagnoles du Golfe de Gascogne, surtout dans la zone du plateau continental.

Il est impossible de donner un aperçu de tous les résultats importants exposés par le Dr. l e D a n o i s, car les régions étudiés sont aussi différentes au point de vue des conditions océanographiques qu'éloignées au point de vue géographique. L'interprétation des faits d'observation ne ralliera peut-être pas l'accord unanime des hydrologistes, quelques-uns des problèmes soulevés étant de ceux qui, par la complexité de leur nature, sont encore l'objet de controverses que seuls de nouveaux progrès des connaissances parviendront à résoudre de façon tout à fait satisfaisante.

Je profite de cette occasion pour me permettre d'attirer l'attention des biologistes en particulier sur la signification très conventionnelle de quelques termes employés couramment par les hydrologistes, termes qui, pris à la lettre, pourraient mener à des conceptions assez éloignées de la réalité. Telle est le cas, par exemple, pour l'expression "Cold wall" ou "Mur froid" appliquée à la zone, située à l'Est et au Sud-Ouest des Bancs de Terre Neuve,

où il existe un changement très marqué de la température (et de salinité), et cela depuis la surface jusqu'à une grande profondeur de la mer. En regardant les représentations graphiques habituelles de cette distribution des caractéristiques océanographiques en question, on serait enclin à supposer qu'il s'agit d'un changement vertical, ou presque, du trajet des lignes et des surfaces isothermiques et isohalines, changement qui serait plus ou moins comparable à la disposition d'un mur sur un terrain. Ce n'est qu'une impression créée par l'exagération formidable de l'échelle verticale du dessin par rapport à celle des distances horizontales, ce qui, d'ailleurs est indispensable comme artifice pour l'étude et l'exposition des variations de ces caractéristiques. Il suffit, pourtant, de faire un calcul très simple avec les données de l'observations pour constater que la réalité est très différente de l'image fournie par cette sorte de diagrammes. Prenons, par exemple, les données obtenues par les recherches du "Président Théodore Tissier". La pente moyenne réelle des lignes isothermes les plus inclinées, entre deux stations situées à l'Est du Bonnet Flamand, celles nos. 357 et 359, serait de l'ordre de 1 pour cent. Même entre les stations 357 et 358 (distance 51 Km.), comme l'isotherme de 7° passe de 500 m. environ à un peu plus de 50 m., on voit que la pente moyenne n'est que de l'ordre de 0·9 pour cent. Un calcul identique pour un autre groupe de stations de la section établie le long du 45° de latitude nord (stations 234 à 236), donne des pentes moyennes encore inférieures, de l'ordre de 0·5 pour cent seulement. Il se peut, évidemment, que des observations encore plus rapprochées montrent des variations un peu plus considérables dans ces régions, mais il semble ressortir de ces quelques exemples que les faits ne s'éloigneront pas beaucoup de cet ordre de grandeur, tout au moins pour ce qui a trait à de grandes masses d'eau, comparables en dimensions à celles ici considérées.

A. Ramalho.

H. Wattenberg. "Kohlensäure und Kalziumkarbonat im Meere." Fortschr. Mineral., Kristallogr. u. Petrogr. Bd. 20, S. 168—195, 7 Abb. Berlin, 1936.

For many years much speculation has been devoted from the viewpoints of biology, geology, and chemistry to the role played by calcium carbonate in sea water and bottom deposits, and to the associated equilibria existing in sea water between carbon dioxide, carbonic acid, and the bicarbonate-, carbonate-, and hydrogen-ions. Standing in the way of an understanding of this complex system was the complete failure of the then chemical theory to interpret the experimental findings, these findings themselves often being of uncertain value.

Following the publication of theories of strong electrolytes by Milner and Bjerrum and of the introduction of the concept of activity, great advances were made possible. In these advances K. Buch and Wattenberg himself took the lead, and as a result of their labours the calcium carbonate system is now one of the best understood of sea water equilibria. In their magna opera (Buch, Harvey, Wattenberg, and Gripenberg, "Über das Kohlensäuresystem im Meerwasser," Rapp. et Proc.-Verb, Vol. LXXIX, pp. 1—70, 1932; and Wattenberg, "Kalziumkarbonat- und Kohlensäuregehalt des Meerwassers." Wiss. Ergebn. deutsch. atlant. Exped. "Meteor", Bd. VIII. Berlin u. Leipzig, 1933) the exhaustive treatment written in physico-chemical language must of necessity make heavy reading for biologists and geologists unfamiliar with recent developments of chemical theory. It is to these that the present paper is addressed. The

paper first epitomizes the chemical theory, stress being laid upon those factors which caused the apparent breakdown of the law of mass action in the earlier investigations. In the result theory and experiment have been brought into surprisingly good agreement. The factors affecting the solubility of calcium carbonate in sea water are gathered into two groups: —

1) Those raising the solubility: —

a) Increase of CO_2 content causing displacement of the equilibria: —

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3'$$
$$HCO_3' \rightleftharpoons H^+ + CO_3''$$
$$Ca^{++} + CO_3'' \rightleftharpoons CaCO_3$$

b) Increase of salinity. Neutral salts dissociate into charged ions which, particularly the divalent ions, exert a strong polar effect on the ions taking part in the above equilibria. The solubility product of calcium carbonate is especially affected.

c) Increase of hydrostatic pressure with depth affects both the solubility of calcium carbonate and the carbonic acid equilibria.

2) Those lowering the solubility: —

a) Increase of temperature

b) Increase of the concentration of calcium-ion.

In sea water these factors largely cancel out, so that we find that in the end the solubility of calcium carbonate in sea water is not so very different from what it is in distilled water.

Accounts equally succinct are given of the CO_2-pressure at the surface of the sea and of the exchange of CO_2 with the atmosphere, the distribution of carbonic acid in deep water and in the sea bottom, of solution of calcium carbonate from bottom deposits and of deposition of chalk by biological and inorganic processes. These sections largely recapitulate Volume VIII of the "Meteor" Reports, the review of which (J. du Conseil, 1934, IX, pp. 263—5) in the main applies here also.

To conclude, it may be said that there is little that is new in this paper, for, professedly, it is itself a review. None the less it ought to be of value to every one interested in the marine merry-go-round, whether his own interests lie in corals and atolls, or lamellibranchs and pteropods; in the sea as regulator of atmospheric composition or as source of sedimentary rocks, or merely in an application of modern chemical theory to an interesting biological problem.

L. H. N. C.

H. Wattenberg und H. Meyer. "Der jahreszeitliche Gang des Gehaltes des Meerwassers an Planktonnährstoffen in der Kieler Bucht im Jahre 1935." Kieler Meeresforsch., Bd. I, S. 264—278, 6 Abb. Kiel, 1936.

In Kiel Bay water samples were collected every fortnight during one year, February 1935 to February 1936, at the surface and at the 15 m. level, 1 m. above the bottom. The water samples were analysed for salinity (by means of the Zeiss refractometer), ammonia, nitrite, phosphate, and silica content. Temperature observations were also carried out.

Hydrographically Kiel Bay, in its deep parts, may be regarded as belonging to the North Sea, while the surface waters are predominantly of Baltic origin. The influx of deep water takes place through the Great Belt.

The annual cycle of phosphate and silica in Kiel Bay was compared with that observed in the English Channel by Atkins and Cooper. The authors found that while in the Channel the concentrations between

the spring maximum and the increase in autumn run fairly parallel for the surface and the bottom layers, in Kiel Bay a pronounced differentiation takes place from June, the surface layer becoming poorer, while in the bottom waters the concentration increases. In autumn the changes go the other way, the concentration of the upper and lower layers converge and later reach the winter values. The cause of this difference between the two coastal areas the authors find in the different density conditions in the two regions. In the English Channel the stratification in summer is mostly a thermal phenomenon, whereas the stratification in density observed in Kiel Bay at this time of the year is mostly due to salinity differences. By means of German lighthouse records of temperature and salinity at various depths and the observations by Cooper in the English Channel, the authors show that the thermal stratification may be easily broken down by wind action, while even strong wind did not destroy the stratification in salinity of waters similar to those observed in Kiel Bay.

The ammonia content varied between 0 and 20 mg./m.^{3}, the distribution being rather irregular. The nitrite values were of similar order, being higher in the deep waters than at the surface. The courses of the ammonia and nitrite curves could not be interpreted in detail, but the following features of the two curves were found to be significant. During summer an increase in the ammonia content was followed by an increase in the nitrite values. The nitrite maximum occurred about one month later than the corresponding ammonia maximum, a finding which corroborates Cooper's interpretation of the records from the English Channel, viz., nitrite occurring as an intermediate product in the oxidation of ammonia to nitrate.

Since the plankton investigations were of a preliminary nature, they were confined to observations on the amount of surface plankton retained by a Kolkwitz-sieve. According to these observations, the spring diatom maximum occurred in March, while an autumnal phytoplankton maximum was recorded for October. The *Ceratia* population in October reached 18,600 /L. The numbers of copepods and nauplii recorded by this method indicated a nauplius maximum in June and a maximum of copepod adults in July.

This valuable contribution gives another example of the variation in the physico-chemical factors of plant production.

T. B.

K. Lüders. "Die Messung der Sandwanderung in der Flachsee mit Gezeiten." Senckenbergiana. Bd. 18, Nr. 3/4, S. 121—130, Abb. 5. Frankfurt a. M., 1936.

The direct measurement of sand transport receives a great deal of attention nowadays. It seems that this research has been neglected too long. Local engineers should know the principles of the currents and their transports in harbours, channels, and inlets. Often it is not known whether the sands that have to be dredged, are of fluvial or of marine origin.

The paper of Dr. Lüders provides an opportunity to describe the different types of instruments used nowadays.

The first engineer who started the study of sand transport by stream was Canter Cremers from the Dutch Rijkswaterstaat (Fig. 1, 1918). The mixture of sand and water enters at O and leaves at V behind a collar, which causes the right amount of suction. The inside being wide, the sand settles there. Fine silt passes through it, however, and rolling material cannot enter at O.

Herr L ü d e r s describes an instrument in use at Wilhelmshaven since 1931. It is intended to show the amount of sand rolling over the bottom (Fig. 2). The floating material cannot be arrested with it properly.

Another instrument able to catch rolling material is the one given in Fig. 3. A kind of trawl-net (fine copper screen) placed on the bottom

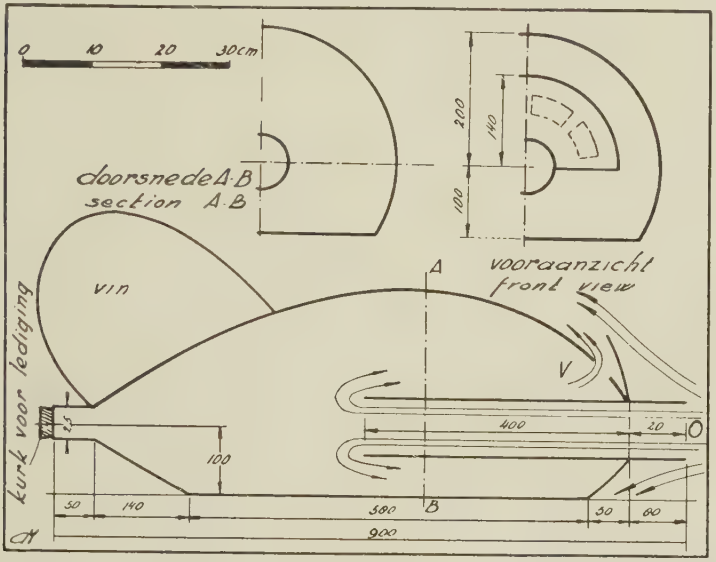

Fig. 1. "Sand-trap" of C a n t e r - C r e m e r s for floating sand (1918).

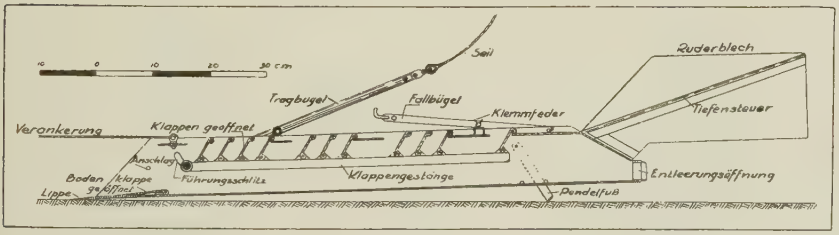

Fig. 2. "Sand-Falle" of L ü d e r s for rolling sand (1931).

catches the sand and stones up to a certain size. Fine material chokes the meshes. Therefore this instrument is used in the higher reaches of rivers only. Though originally a German invention ("Alberich"), S c h a a n k (1936) improved it by adding a collar, producing some necessary suction.

Still another instrument in use is a sample-taker (v a n V e e n, 1930, Fig. 4) consisting of short square tubes, through which the water and sand may pass without hindrance. It is placed as gently as possible on the bottom by means of buffers (not shown in the figure). Rolling sand may therefore enter. By a falling weight the tubes are shut suddenly, so that 4 samples

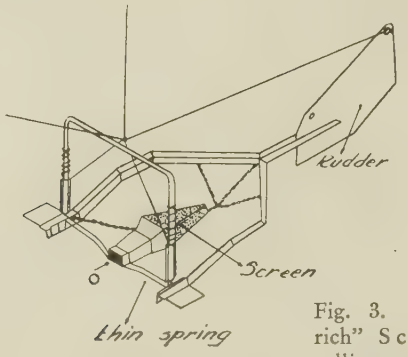

Fig. 3. "Sand-net" (system "Alberich" Schaank improv. 1936) for rolling and floating coarse material.

are taken simultaneously from the bottom up to 70 cm. above it. The contents of silt and sand, as well as the salinity and temperature of these samples can be measured.

Large-scale investigations have been going on in the Dutch rivers, seas, and inlets since 1930 with 4 or 5 measuring boats. The instruments in use are those pictured in Figs. 2, 3 and 4. In German waters (Ems, Wilhelmshaven, on the Rhine, etc.) sand transportation is investigated with the instruments pictured in Figures 2 and 3.

v. V.

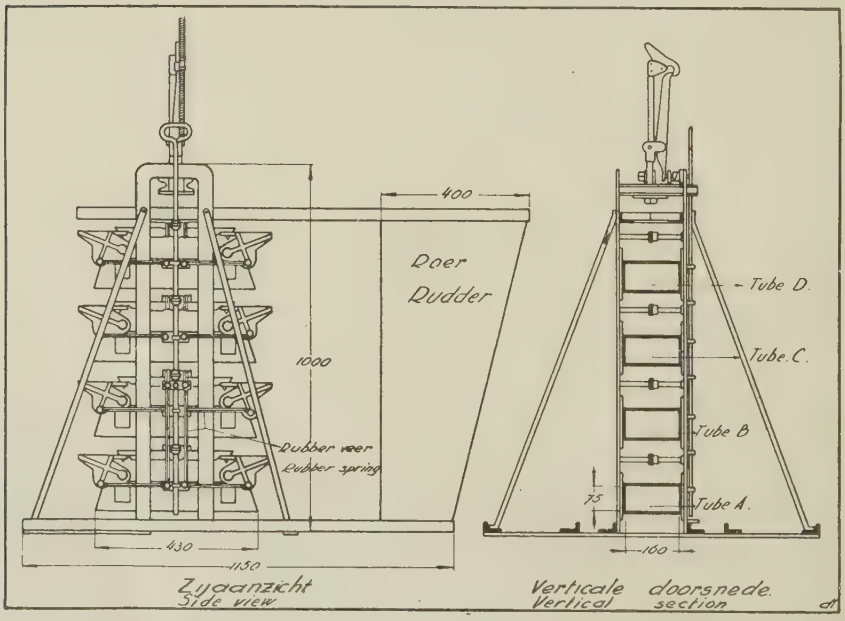

Fig. 4. "Sample taker" of van Veen (1930) for rolling and floating fine and coarse material. Tubes A, B, C, and D sink slowly towards the bottom through the frame. In the figure the lowest point is not reached.

H. Schmidt-Ries. "Grundsätzliches zur Zentrifugenmethode." Arch. f. Hydrobiologie. Bd. XXIX, S. 553—616. 1936.

In dieser sehr eingehenden, sich auf mathematische Berechnungen stützenden Arbeit wird die Leistung der Zentrifugenmethode bei quantitativen Planktonarbeiten behandelt. Es wird gezeigt, dass eine Fixierung der Planktonprobe notwendig ist. Hierbei empfiehlt der Verfasser KJ + J. Eine Lebenduntersuchung bedeutet eine ständige Fehlerveränderung, deren unregelmässige Grenzen unbestimmbar sind. Zur Beurteilung der Zentrifugenmethode wird die Kammermethode (umgekehrtes Mikroskop) benutzt. Bei dieser kommen nach Angabe des Verfassers nur zwei Fehlerquellen in Betracht; der sogenannte Füllungsfehler und der Fehler bei der Auszählung.

Bei der Zentrifugenmethode kommen noch eine Reihe weiterer Fehlerquellen hinzu. Erstens werden die Instrumentalfehler der Zentrifuge und der Gläser erwähnt. Diese verändern sich sehr nach dem Bau der Zentrifuge und der Gläser und nach der Tourenzahl der Zentrifuge. Eine weitere Reihe Fehler sind die Zentrifugalfehler. Als solche werden angegeben: Schädigung der Planktonten beim Zentrifugieren, Hängenbleiben der Planktonten an den Glaswänden infolge einer Stauerscheinung beim Zentrifugieren und Aufwirbeln des Sediments bei der Bremsung der Zentrifuge oder durch Konvektionsströme, die teils durch Erwärmung, teils durch Verdunstung an der Oberfläche hervorgerufen werden. Auch der Triptongehalt kann eine beträchtliche Fehlerquelle bieten. Starker Triptongehalt zwingt zur Benutzung kleinster Wassermengen, falls nicht überhaupt jede Zentrifugierung unmöglich ist. Eine ganz bedeutende Fehlerquelle entsteht durch das Übertragen des Sediments auf das Objektglas. Auch eine Reihe anderer Möglichkeiten sind vorhanden, die beträchtliche Fehler veranlassen können.

Der Verfasser kommt zu dem Schluss, dass die Zentrifugenmethode nicht den Anforderungen einer quantitativen Verarbeitungsmethode entspricht.

Ein umfangreiches Kapitel hat der Verfasser den Teilzählungen des Sediments gewidmet. Es wird untersucht, wie gross die Fehler sind, wenn anstatt einer Vollzählung nur ein gewisser Teil gezählt wird. Die Genauigkeit hängt vor allem von der Zahl der Individuen im Sediment ab; der Fehler kann beträchtlich sein.

Zum Schluss schreibt der Verfasser: "Trotz der schwerwiegenden Feststellungen über die Leistung der Zentrifugenmethode ist es kaum zugänglich, sie auf Grund dieser einen Untersuchung als nur qualitative Methode zu bezeichnen." Hierin kann ich dem Verfasser nur beistimmen. Bei den meisten quantitativen Planktonarbeiten sind es nur die sehr grossen Schwankungen, die Interesse haben. Es ist von Wichtigkeit zu wissen, ob z. B. 1,000 oder 10,000 Organismen pr. l. vorhanden sind. Ob z. B. 1,000 oder 1,683 wirklich vorhanden sind, ist von ganz minimalem Interesse. Die mathematischen Berechnungen, die bei einer theoretischen Arbeit wie der vorliegenden berechtigt sind, spielen bei den meisten praktischen Arbeiten überhaupt keine Rolle. Hier würden sie nur ein Appendix *ad ornandum* sein. Obgleich die Resultate z. B. von Hentschel auf der "Meteorexpedition" zweifellos grosse Fehler aufweisen, haben sie doch einen bedeutenden wissenschaftlichen Wert. Trotz allem zeigen sie die grossen Züge der Planktonverteilung im Atlantischen Ozean.

Etwas Anderes ist es natürlich, dass man bei allen modernen quantitativen Phytoplanktonuntersuchungen die Methode von Utermöhl (Röhrenkammer + umgekehrtes Mikroskop) benutzen sollte. Grade der Referent hat im Vol. VIII dieser Zeitschrift die Überlegenheit dieser Methode bei marinen Planktonarbeiten gezeigt.

E. Steemann Nielsen.

M. V. Lebour. "Notes on the Plymouth *Processa* (Crustacea)." Proc. Zool. Soc. London. Pt. 3, pp. 609—617, 6 Plates. London, 1936.

Miss Lebour has again proved the importance of an exact study of larval Decapoda. Having observed that among the larvae attributed to *Processa canaliculata* there are small but constant differences, she proceeded to a detailed examination of the adults from various localities, with the result that she has demonstrated the presence of two species where only one had hitherto been known. To the smaller, stouter, form common in inshore waters at Plymouth she has attached the name *P. edulis* (Risso) since this proves to be also the common littoral species of the Mediterranean. Leach's original *P. canaliculata* is larger, with longer legs, and is found in deeper water. There are other small, but still constant and positive, characters by which the species can be recognized, and it will be necessary to take these characters into account in all future dealings with the genus. Literature abounds in reference to "*P. canaliculata*" from all over the world, and it has also often been figured and described, but neither figures nor descriptions permit decision in most cases as to which, if either, of the two species was at hand. Only one thing is certain, that *P. canaliculata* is not the cosmopolitan species it was supposed to be. The paper, with its accurate figures, lays a sure foundation of knowledge of the genus in larval and adult phases, and it is to be hoped that it will influence those who describe new species of Decapoda to make their descriptions more thorough and their figures more convincing. Lastly, mention may be made of the beautiful coloured drawing of the post-larval *P. canaliculata* made over thirty years ago by Mrs. Sexton. The combination of the greatest accuracy in drawing of detail with delicacy and truth in colouring is rare and satisfying.

R. G.

F. C. Fraser. "On the Development and Distribution of the Young Stages of Krill *(Euphausia superba)*." Discovery Rep. Vol. XIV, pp. 1—192. Cambridge, 1936.

This most interesting memoir deals with the development of *Euphausia superba*, the whale "Krill" of the Antarctic, during a period covered by the first fifteen months of growth, together with the distribution, horizontal and vertical, and time of occurrence of the various stages. It has been shown already by Dr. J. F. Wheeler (1930) that there is a two-year developmental period in *E. superba* as opposed to a one-year period in other euphausians whose life history is known.

The importance of a thorough knowledge of every stage in the development is great, and the large amount of material available has afforded a unique opportunity for studying all these stages and has enabled the author to form certain general conclusions which affect not only this species but all members of the group and probably the whole of the Decapoda. This is specially the case with the furcilia stages and the development of the pleopods. Here he has established the principle that there are certain important essential stages recognized by the number and state of development of the pleopods and that these stages predominate to such an extent that one must regard any intermediate stages, hitherto usually thought to be equal in value to the others, as merely unessential varieties which only occur occasionally. It has been shown by various authors dealing with different species that certain furcilia stages are dominant and often only these are found, but their true significance was not sufficiently recognized. Another observation is interesting that the number of non-setose pleopods present

in any one stage indicates the number of setose pleopods in the stage immediately following. The author sweeps away altogether the cyrtopia (intermediate between furcilia and young) and arranges the various stages into furcilia groups, characterized by the developmental state of the pleopods and telson. The term "post-larval" for the stages succeeding the cyrtopia, or, in the present work, late furcilia, has already been abandoned by some workers, for these stages gradually merge into the adult, and the term "adolescent" is substituted. It is to be remembered, however, that euphausian development is very gradual, moults being frequent and the change in each moult slight.

Length of body is discussed in detail, and it is a curious fact that some of the larvae in the second season are much larger than the majority, and this occurs simultaneously in the same locality and also in different localities at approximately similar times. There is no definite conclusion, but a suggestion as to correlation of early larvae with abundant plankton. Growth is not regular but slows down in winter.

Study of the distribution demonstrates clearly that breeding takes place in the deep water rather than in the shallow, and eggs, nauplii, and metanauplii are found in the deep water of the far south, calyptopis and early furcilia stages in warm deep water and in the immediate vicinity of Antarctic surface water, but the late furcilia stages and adolescents persistently occur at the surface and are distributed at the ice edge. The early stages have a well-defined diurnal vertical migration and the adolescents remain continually at the surface. With advancing development there is a lengthening of time of occurrence, an important fact, as thus a constant supply of food is ensured for the whalebone whale in the south.

M. V. L.

D. D. John. "The Southern Species of the Genus *Euphausia*." Discovery Rep. Vol. XIV, pp. 192—324. Cambridge, 1936.

The adult characters of ten species of *Euphausia* are described in this work and the development of five of them. *Euphausia superba* is included in the adult description, its development having been described already by Fraser (see above). It is curious that whilst Fraser, following Rustad and others, abandons the term "post-larva" in favour of "adolescent" for those forms which are intermediate between the cyrtopia (here regarded as late furcilia) and adult, the present author should revive it. Although the name given to such stages is unimportant so long as it is well defined, it seems a pity that two important works, based on closely related material, published almost simultaneously and in the same publication, should not agree in such small matters.

The southern species of *Euphausia* described here fall into two natural groups and their distribution is very interesting, showing that, if it be supposed that the genus arose in warm water, colonization took place along two distinct lines, one very complete and reaching to the far south, the other not so complete and not breeding so successfully. In the latter group consisting of *Euphausia hanseni, E. spinifera, E. longirostris,* and *E. triacantha* it is shown that each of the four species occupies one of four successive zones of water from north to south, *E. hanseni* being the most northerly, *E. triacantha* the most southerly. *E. spinifera* and *E. triacantha* are much alike and the larvae of *E. longirostris, E. spinifera,* and *E. triacantha* are closely similar, especially the first two. In the second group, the so-called Southern Group, comprising *E. lucens, E. vallentini, E. frigida, E. superba* and *E. crystallorophias,* all the species are circumpolar in range, and the author believes from

structural evidence that they form a series representing colonization in the order given, *E. frigida* possibly giving rise to both *E. superba* and *E. crystallorophias,* the latter being neritic. The chief morphological characters relied on are the male pleopods which appear to be of extreme importance in this connexion.

The developmental stages described are of interest and show that *E. frigida* and *E. vallentini* are closely related and are, with *E. superba,* of a different type from the other three described which belong to the Southern Group. In both groups dominant furcilia stages are much in evidence and there are few, in some cases no, intermediate variations, a distinct tendency to a shortening of the life history being shown.

This paper and Mr. Fraser's form an important contribution to the study of the Euphausiaceae.

M. V. L.

F. Bernard et L. Fage. "Recherches quantitatives sur le plancton méditerranéen. Note préliminaire." Bull. de l'Inst. Océanogr. No. 701, pp. 1—20, 1 Fig. Monaco, 1936.

The authors are studying the nannoplankton in three localities, the stations chosen being at Monaco, Villefranche, and Banyuls, all varying much as regards coast, sea bottom, and currents. Samples are taken at each station at 10, 50, and 350 metres, the last reaching the zone rich in nutritive substances. Phosphates, nitrates, and silicates are sampled at the same time. The methods employed for collecting and estimating the plankton consist of a water-bottle (Richard) which samples at known depths, and a reversed microscope as used by Steemann Nielsen (1933) for counting the organisms brought down by sedimentation. The fresh samples are fixed rapidly in neutral formol and preserved in beer bottles. This method of counting the nannoplankton is very effective and retains a very large number of the smallest plants and animals.

In agreement with other workers in the Mediterranean (especially Schiller and Lohmann at Syracuse and in the Adriatic) it is found that there is an enormous quantity of flagellates throughout the year, especially coccolithophorides. The flagellates altogether may represent at least a quarter and sometimes half of the total protists.

As a preliminary some of the results at Monaco are given, taken in the spring of 1936. In comparison with the northern seas, sampled by Steemann Nielsen in the same way, there is a great poverty of diatoms and of Peridiniales *(Peridinium* and its close relatives), but the phytoflagellates, Thecatales *(Exuviaella* and *Prorocentrum)* and Gymnodiniales appear to be at least as abundant as in the open seas.

It is very interesting that the density of the Coccolithophorids and Thecatales is so uniform from the upper to the deeper water layers. The authors suggest that a good number of the phytoflagellates are capable of living a non-autotrophic life in the absence of light, for *Coccolithus pelagicus* and *Acanthoica* abound even at 1000 metres depth.

The figure showing the distribution in depth of the microplankton on March 31st 1936 between the stations II and III at Monaco is very instructive, and there are two tables recording the composition of the plankton in February—March and April—May at Station II.

M. V. L.

H. H. Gran and T. Braarud. "A quantitative study of the phytoplankton in the Bay of Fundy and the Gulf of Maine (including observations on hydrography, chemistry & turbidity)." Journ. Biol. Board Canada, Vol. I, No. 5. Toronto, 1935.

A series of stations was worked each month from April to September in the Bay of Fundy and the Gulf of Maine. The salinity, temperature, phosphate, nitrate, and oxygen content of the waters were observed and the phytoplankton population found by the centrifuge method. The considerable data so obtained are clearly set out in this monograph.

In the clear waters of the Gulf of Maine the conditions in which the phytoplankton grows and the annual changes and nature of the plants are similar to those in the coastal waters of northern Europe. A maximum is reached in April—May composed of diatoms, succeeded by a dinoflagellate-diatom-coccolithophore community. When the nutrient salts in the upper layers have been consumed and reduced by the diatoms and the waters become stratified, further growth is limited and the rich diatom plankton gives way to the dinoflagellate community. Then during the summer greatest growth occurs where the stratification is least marked as over Georges Bank, and close to the coast. The effect of turbulence on the productivity is favourable, the supply of nutrient salts from below having a favourable effect exceeding the unfavourable effect brought about by organisms being carried into depths where there is insufficient light.

In the Bay of Fundy the conditions for plant growth are different. On account of the exceptionally high tidal range, the turbulence of the water is so strong throughout the year that the phosphate and nitrate content was nearly always found to be high, even at the surface. The production of phytoplankton, therefore, can hardly be limited by lack of nutrient salts. The relatively high turbidity of the water makes the productive zone shallow. Furthermore, frequent fog reduces the intensity of illumination, particularly during the summer months. A rich diatom plankton was found in the Bay in April/May, except along the New Brunswick coast. In May the illumination was at its maximum for the year. In June the situation was quite changed and showed a striking contrast to that of the Gulf of Maine. In Passamaquoddy Bay where the waters were stratified the diatom plankton was still rich, but elsewhere the waters were nearly barren, although the nutrient salt content was high, even at the surface.

"While during summer the production of phytoplankton in the surface layers of the Gulf of Maine is mainly limited by the low contents of phosphate and nitrate, caused by a marked stratification, we find quite the inverse situation in the Bay of Fundy. Here the phosphates and nitrates are, particularly in June, present in excess, but the phytoplankton is nevertheless poorer than in the Gulf of Maine, and in June extremely poor. The only possible explanation of this seems to be that the phytoplankton is prevented by turbulence from accumulating in the illuminated zone. As this zone is shallower than in the Gulf of Maine because of the weaker illumination and turbidity of the waters, the photosynthesis of the plankton algae, moving up and down with the turbulent waters, may be insufficient to counterbalance their respiration or to give a surplus sufficient to cover the consumption by animals."

An experiment was made in Passamaquoddy Bay to determine the depth of the compensation level, which was found to lie some 17 metres below the surface during the six hours of the experiment on a clear day in June. Hence the layer in which photosynthesis will exceed respiration of a daily

period of 24 hours is a singularly shallow layer, not likely to exceed 10 metres during summer in the Bay of Fundy.

This survey was made with the object of predicting the effect of a proposed dam across the entrance of Passamaquoddy Bay upon the productivity of the region; it has shown an instance where excessive vertical mixing has an unfavourable effect upon the productivity, such as had been foreseen, notably by Gran and by Hart, to act upon the growth of phytoplankton in antarctic seas.

H. W. H.

A. C. Hardy. "The Continuous Plankton Recorder." Discovery Rep. Vol. XI, pp. 457—510. Cambridge, 1936.

Die Arbeit enthält in der Hauptsache eine eingehende Beschreibung mit zahlreichen genauen und klaren Abbildungen von Hardy's grossem, automatischen Planktonsammelapparat, dem "Recorder" (im Gegensatz zu dem kleinen, nicht automatischen "Indicator"). Der Zweck des Apparats ist der, den Zustand des Planktons auf längeren Strecken Meile für Meile bei voller Fahrt zu registrieren. Er gestattet so einerseits, die Veränderungen der Planktonzusammensetzung von Ort zu Ort im einzelnen zu studieren, und ermöglicht andererseits, wenn mehrere Apparate von verschiedenen Handelsschiffen in einem Meeresgebiet gleichzeitig benutzt werden, periodische Gesamtüberblicke über dessen Planktonzustand. Die Hauptzüge seiner Konstruktion sind folgende: Ein länglicher nach beiden Enden verjüngter, im Querschnitt rechteckiger, vorn mit einer Einströmungsöffnung und hinten mit einer Ausströmungsöffnung versehener Behälter enthält in seinem Innern eine senkrecht zur Hauptachse stehende Gazescheidewand, die das Plankton aus dem durchströmenden Wasser herausfischt. Im Gegensatz zum Indicator ist diese aber durch ein Räderwerk beweglich, ist ein Teil eines Gazebandes, das sich langsam während der Fahrt senkrecht durch den Weg des durchströmenden Wassers schiebt. Das Räderwerk ist durch einen vom vorbeiströmenden Wasser getriebenen Propeller in Bewegung gesetzt. Das von unten kommende Gazeband trifft, nachdem es oben den Kanal wieder verlassen hat, auf ein zweites Band derart, dass das auf dem ersteren abgelagerte Plankton von diesem zweiten zugedeckt und somit festgehalten wird. Beide zusammen werden schliesslich auf einer Rolle innerhalb eines Formalinbehälters lose aufgewickelt. Das Band ist in regelmässigen Abständen mit Querstrichen und Nummern versehen, sodass sich mit Hilfe der Logablesungen feststellen lässt, welchem Teil der Fahrt jeder einzelne Teil der Planktonablagerung entspricht. Die Untersuchung geschieht unter einem an einem horizontalen Arm verschiebbaren Mikroskop auf zwei benachbarten Glastischen, über die die beiden Gazestreifen, durch ein Räderwerk wieder auseinandergewickelt, mit ihrer Innenfläche nach oben hingleiten. Auf die Einzelbeschreibung kann hier nicht eingegangen werden, es seien nur noch folgende Masse angegeben: Der Apparat ist etwa 1 m. lang, die Einströmungsöffnung ist 3·18 cm. weit, kann aber auf 1·9 cm. verengert werden, die jeweils exponierte Gazefläche misst 10·2 × 3·2 cm., die Gazesorte ist Nr. 3. Es werden ferner Angaben gemacht über die Entwicklung des Apparats, über seine Behandlung, über Fehlerquellen (Verstopfung, tageszeitliche Vertikalwanderungen, Schädigung des Planktonsmaterials) über mögliche Weiterentwicklungen, über das Fangvermögen und über die Deutung der Ergebnisse.

In einem besonderen Anhang prüft der Verfasser in Gemeinschaft mit N. Ennis die Leistungsfähigkeit des Recorders auf Grund von Parallelfängen mit dem Indicator.

E. H.

A. C. Hardy. "Observations on the uneven Distribution of Oceanic Plankton." Discovery Rep. Vol. XI, pp. 511—538. Cambridge, 1936.

Die Arbeit bietet in graphischer Darstellung und kurzer Besprechung die Ergebnisse von 35 Fängen mit dem Plankton-Recorder im südatlantischen Ozean während der "Discovery"-Expedition. Die untersuchten Fahrtstrecken waren zwischen 23 und mehr als 100 Sm., zusammen 2300 Sm. lang und verteilten sich von den Tropen bis zur Antarktis. Der Zweck war eine vorläufige Bestimmung des Umfangs der Fluktuationen der Planktonbevölkerung. Die Ergebnisse werden benutzt, um den alten Streit zwischen Haeckel und Hensen über die Frage der Gleichmässigkeit oder Ungleichmässigkeit der Planktonverteilung im offenen Ozean zu beurteilen. Der Verfasser kommt zu einer Entscheidung zu Gunsten Haeckels, d.h. zu Gunsten einer ausgesprochen ungleichmässigen Verteilung. Bei der Besprechung der Einzelfänge werden regelmässig die Copepoden, häufig die Euphausiden und Chaetognathen, nicht selten *Limacina* und Salpen, gelegentlich Diatomeen und andere Gruppen, teils als Ganzes, teils in bezug auf einzelne Gattungen besprochen. Die Kurven zeigen überall beträchtliche Schwankungen, doch verschieden bei den verschiedenen Gruppen, besonders stark z. B. bei den Salpen. Ein Teil der Schwankungen scheint auf tageszeitliche Vertikalbewegungen zurückführbar zu sein, manche auf eine Wechselwirkung zwischen Phytoplankton und Zooplankton. Nur selten stimmen die Kurven verschiedener Gruppen, z. B. Copepoden und Chaetognathen, im gleichen Fang überein. Zum Schluss werden die Ergebnisse einer ununterbrochenen Reihe von 57 Netzfängen auf einer Strecke von 19 Sm. besprochen. Auch sie zeigen starke Schwankungen. Die Kurven scheinen z. T. auf das Bestehen regelmässiger doch verschiedenartiger Rhytmen der Fluktuation hinzudeuten.

Der Berichterstatter hat keine Veranlassung, die tatsächlichen Ergebnisse der Arbeit zu beanstanden. Er kann sich jedoch nicht davon überzeugen, dass die Anschauungen Hensens dadurch widerlegt, die Haeckels bewiesen seien. Wenn Hensen auf jeder der mit dem Recorder bearbeiteten Strecken nach seiner Methode einen Vertikalfang von 200 m. gemacht hätte, so würde er der Wahrscheinlichkeit nach Werte gefunden haben, die den Mittelwerten der entsprechenden Recorderkurven mehr oder weniger proportional wären. Diese Mittelwerte sind nun gebietsweise sehr verschieden. Man erkennt das schon an den sehr verschiedenen Skalen der graphischen Darstellungen etwa bei den Copepoden. Und sie sind für die einzelnen Gebiete augenscheinlich durchaus im Sinne Hensens charakteristisch. Trägt man z. B. die Copepodenmittelwerte in die nach Hensens Grundsätzen erarbeiteten Grundkarten der "Meteor"-Expedition (Wiss. Erg. D. Atl. Exp. Bd. 11, Beil. 1 und 2) ein, so fallen die (schätzungsweise) dreistelligen, d. h. hohen Mittelwerte der Recorderkurven durchweg in planktonreiche, die einstelligen durchweg in planktonarme Gebiete. Hensen hat nicht geleugnet, dass Schwankungen wie die hier nachgewiesenen vorhanden sind, sondern dass sie von Belang sind. Die Ergebnisse der "Deutschland"-Expedition und der "Meteor"-Expedition sprechen in dieser Frage — die man heute allerdings wohl anders formulieren müsste — durchaus für Hensen und gegen Haeckel.

E. H.

A. C. Hardy, C. E. Lucas, G. T. D. Henderson and J. H. Fraser. "The Ecological Relations between the Herring and the Plankton investigated with the Plankton Indicator". Parts I—IV. Journ. Mar. Biol. Assoc. N.S., Vol. XXI, No. 1, pp. 147—292. Plymouth, 1936.

Hardy gibt nach einem kurzen Überblick der früheren Angaben über die Zusammenhänge zwischen Planktonverteilung und Heringsvorkommen, sowie über seine eigenen früheren Versuche eine Beschreibung seines verbesserten Planktonanzeigers (Plankton Indicator). Das Instrument, bekanntlich ein torpedoförmiges, vom Schiff nachzuschleppendes Fanggerät, ist jetzt 56 cm. lang, 9 cm. breit und mit einer 3·8 cm. weiten Einströmungsöffnung versehen. Es hat im Innern, senkrecht zur Längsache in einen Ring gespannt, ein auswechselbares Stück Planktongaze (60 Maschen auf den Zoll, d.h. Nr. 3 der deutschen Bezeichnungsweise), durch welches das Wasser hindurchströmt. Durch ein System von Flügeln wird bewirkt, dass der Anzeiger bei normaler Fahrt mit 10 Faden Leine in etwa 4—5 Faden Tiefe dem Schiffe folgt. Er wird so 1 Sm. weit geschleppt und dann zum Auswechseln der Gazescheibe eingeholt. Der praktische Endzweck ist, dass der Fischer nach mehreren Seemeilen Fahrt aus dem Vergleich der Gazescheiben erkennen soll, wo das reichste *Calanus*-Plankton steht und daher mit grösster Wahrscheinlichkeit Hering zu erwarten ist. — Die Prüfung der Fangkraft des Instruments ergab im Mittel 350 — 400, im Maximum 8000 *Calanus* je Sm. Zahlreiche Umstände erschweren die Erzielung klarer Ergebnisse. Wenn z. B. die Treibnetzfischer den Planktonzustand kurz vor Aussetzen der Netze bestimmen, dann aber stundenlang fischen, so arbeiten sie nicht im ganz gleichen Wasser wie der Anzeiger. Die Vertikalbewegungen des Planktons bedingen einen Einfluss der Tageszeit des Fangens auf das Ergebnis. Auch die Verteilung der Schiffe, die Dauer ihres Fischens und die Länge ihrer Netze sind von Belang. Über 1400 Indicatorfänge wurden in Verbindung mit Heringsfängen ausgeführt. Es ergab sich im allgemeinen eine positive Korrelation zwischen *Calanus*fängen und Heringsfängen (s. u.), doch war es notwendig, die räumlich und zeitlich getrennten Fischereien einzeln und das Zahlenmaterial mehr grössenordnungsmässig zu untersuchen. Entsprechend den wissenschaftlichen Ergebnissen war auch die praktische Verwendung des Anzeigers erfolgreich.

Lucas untersucht die Beziehungen zwischen Zooplankton und Hering im Bereich der englischen Nordseefischerei, Henderson dasselbe für die schottische Fischerei. Dabei werden die Planktonproben für jedes Gebiet in Halbmonatsperioden zusammengefasst und innerhalb dieser mit den zugehörigen Heringsfängen zusammen nach aufsteigenden *Calanus*werten geordnet. Jede solche Reihe wird in eine ärmere und reichere Hälfte geteilt, und für jede von diesen beiden der Mittelwert der Heringsfänge zur Grundlage der Berechnung genommen. Beide Verfasser kommen zu wesentlich übereinstimmenden Ergebnissen. Bei beiden zeigten von 20 Halbmonaten 15 eine positive, 5 eine negative *Calanus*-Heringbeziehung. Es können reiche Heringsfänge in armem *Calanus*wasser gemacht werden und umgekehrt, doch gewöhnlich werden die besseren Fänge in reicherem *Calanus*wasser gemacht.

Bei den Berechnungen über die wirtschaftliche Bedeutung der *Calanus*-Heringbeziehungen, die teils auf Durchschnittswerte, teils auf die Ergebnisse der einzelnen Fahrzeuge gegründet werden, kommen örtliche, jahreszeitliche und jährliche Unterschiede sowie auch Gesichtspunkte des Zeit- und Brennstoffverbrauches und der Preisgestaltung in Betracht. Im allgemeinen werden bei Benutzung des Planktonanzeigers wesentliche Gewinne erzielt, sowohl bei Vermeidung der Gebiete mit der ärmeren Hälfte angehörigen *Calanus*fängen, wie besonders bei Bevorzugung der Gebiete des reichsten Viertels der Fänge. Das Fressen der Heringe, auf dem die Benutzung des Anzeigers beruht, kann

durch die Laichzeit und durch Abweidung der Nahrungsbestände gestört sein. Verstärkter Zufluss atlantischen Wassers während der Untersuchungsjahre 1931—1933 dürfte gewisse Unregelmässigkeiten erklären. Zu reichen *Limacina*beständen scheint der Hering ein negatives Verhalten zu haben. Es werden Mitteilungen über die allgemeine Planktonzusammensetzung der Indicatorfänge gemacht.

Schliesslich untersuchen Henderson, Lucas und Fraser die Beziehungen zwischen dem Hering und dem Phytoplankton. Aus den Fängen von 1930—33 machten ausgeprägt grün oder grünlichbraun gefärbte Gazeflächen eine negative Beziehung des Phytoplanktons zu *Calanus* und *Limacina* sowie zum Hering erkennbar. 1934 wurde in der Herbstfischerei ein Miniatur-Anzeiger von 33 cm. Länge und 2·54 cm. Durchmesser zur Untersuchung des Phytoplanktons allein verwendet, der ähnliche Ergebnisse erzielte und sich als für die praktische Fischerei verwendbar erwies.

E. H.

C. E. Lucas and G. T. D. Henderson. "On the Association of Jelly-Fish and other Organisms with Catches of Herring." Journ. Mar. Biol. Assoc. N.S., Vol. XXI, No. 1, pp. 293—304. Plymouth, 1936.

Bei den Untersuchungen mit dem Hardy'schen Planktonanzeiger wurden die Heringsfischer zu Aufzeichnungen über "Quallen" u. a. Tiere im Fanggebiet veranlasst. Es erwies sich, dass beim Vorhandensein "vieler kleiner weisser Quallen" (Medusen?, Ctenophoren?, z.T. auch Salpen oder Doliolen?) die Heringsfänge oft arm waren, nicht so bei "grossen" und "nesselnden" Quallen. Auch bei Häufigkeit von Tintenfischen, Haien und Walen blieben die Fänge z.T. dürftig.

E. H.

T. S. Rass. "Spawning, Eggs, and Fry of Food-Fishes of the Barents-Sea. Breeding and Development of Fish in Subarctic." Internat. Rev. d. ges. Hydrobiol. & Hydrogr. Bd. 33, H. 3/4, S. 250—270. Leipzig, 1936.

Der Verf., der seit 1930 mit Arbeiten über Fischbrut und -eier bei dem russischen Fischereiforschungsinstitut ("Seefischereiliches und Ozeanographisches Institut") als Sektionsleiter beschäftigt war, hat in englischer Sprache eine kurze und nützliche Übersicht über die Laichverhältnisse usw. der Nutzfische des Barentsmeeres herausgegeben, wobei er sich im wesentlichen auf die Untersuchungen des gen. Instituts stützt, doch selbstverständlich auch die Angaben früherer Untersuchungen von russischen, norwegischen und deutschen Fahrten heranzieht. Das neue Material entstammt den zahlreichen Fahrten mit dem Forschungsdampfer "Persei", dem neueren grossen Forschungskutter "Knipowitsch" und dem kleineren, nur für küstennahe Fahrten dienlichen Motorkutter "Savva Loschkin". Dadurch ist ein sehr reiches, das ganze Barentsmeer deckendes Material gesammelt, und man darf daher wohl annehmen, dass nunmehr die wichtigsten Tatsachen bekannt sind, aus welchen der Verf. im Stande ist, gewisse interessante allgemeine Schlüsse über Laichzeit und -temperatur, Eigrösse und Brutpigmentierung in verschiedenen geographischen Breiten zu ziehen.

O. S.

T. A. Perceva. (Pertsewa). "Key to pelagic eggs of fishes of the Barents Sea." Veröff. des sowj. Seefischereil. & Ozeanogr. Inst. ("VNIRO"), Moskwa, 1936.

Eine Mitarbeiterin in der von T. S. Rass geleiteten Sektion für Fischeier usw. des gen. Instituts hat einen nützlichen Schlüssel, auch mit englischem Text, zur Bestimmung von den im Barentsmeere vorkommenden 10 Arten von pelagischen Fischeiern ausgearbeitet. (Die Zahl der dort vorkommenden Fischarten mit solchen Eiern ist 18, darunter doch einige, deren Eier nicht oder nur sehr selten erbeutet worden sind, z.B. Heilbutt und schwarzer Heilbutt).

Die Eier von *Gadus saida* werden hier zum ersten Mal beschrieben.

Die im Barentsmeere gefischten Eier zeichnen sich im allgemeinen dadurch aus, dass sie erheblich grösser sind und schwächeres Pigment haben.

Der Schlüssel ist mit 36 Abbildungen von Eiern in verschiedenen Stadien versehen.

O. S.

T. Iversen. "Sydøstgrønland, Jan Mayen: Fiskeriundersøkelser." Fiskeridirek. Skr. Ser. Havunders. (Rep. Norwegian Fish. and Mar. Invest.) Vol. V, No. 1. pp. 1—171, 114 Fig. Bergen, 1936.

For a number of years since 1923 fishery consultant Mr. Thor Iversen has cruised in the northern waters during summer on various chartered vessels. In the first years especially the Barents Sea and the waters around Svalbard were explored, but in 1930, 1931, and 1933 the investigations were extended to the waters around Jan Mayen, and in 1931, 1932, and 1933 to Denmark Strait and east Greenland. Mr. E. Koefoed participated in these cruises as a zoologist. In several valuable treatises Mr. Thor Iversen has published some of his rich experiences from the Barents Sea and the Svalbard waters, and the present paper includes an equally valuable survey of the investigations in Jan Mayen and the waters of south-east Greenland. This area, in which comparatively few observations have been made until the last few years, now seems to have been drawn out of the obscurity in which it has lain. This is indeed fortunate, as the physical and biological conditions of this area are of the utmost importance in a consideration of the neighbouring areas, Iceland and west Greenland. It is only possible to obtain an intimate understanding of the animal life when this whole north-western part of the Atlantic Ocean is considered as a whole.

The first 100 pages deal with south-east Greenland, with a mention of the Norwegian hunting stations. Herein are discussed depth conditions, current conditions, drifting ice, meteorological features, and finally the fishing experiments themselves, with a detailed diary of the catch. Professor Helland-Hansen describes in a special part (pp. 80—98) the hydrographical sections. Several maps and very pretty photographs taken by the author illustrate the text. By means of an echo-sounding apparatus installed in 1933 in one of the chartered vessels, "Heimland I", a rich collection of echo soundings has been procured from this area, for which hitherto only a few soundings had been available. The comparatively light amount of ice during the later years has rendered it possible to procure some echo soundings from areas where the ice most often prevents this work. Through Iversen's soundings it has been proved that the Sermilik Deep off Angmagssalik is bordered towards the deep sea by a submarine ridge, which Iversen calls "Heimlandryggen." Towards the south, at least at several places, a similar, somewhat narrower formation is found towards the deep sea. I

mentioned the matter in "Nature", 1934, (p. 326) at the foot of some "Dana" sections. It would be most interesting to find out how this ridge was formed (one can guess that materials have come from the shore and/or have been conveyed by the ice, which melts very quickly in the boundary area towards the warmer water in Denmark Strait). It is to be hoped that the improved sounding technique will in a few years contribute much more data from this most interesting area.

Useful information to those who are working in these waters is given about the ice, the current conditions, and the weather.

The fishing experiments carried out between west Iceland, east Greenland and along the coast of south-east Greenland have been undertaken with various types of long-line and hand-line, and much interesting information is given concerning the catch of both economically important and other species of fish. More measurements of several of the specimens caught would have been valuable but I hope that Thor Iversen will return to the data in later publications. The information about halibut and cod is of great interest, especially the interesting facts concerning the former, which is the most valuable of the rather scanty food fishes taken in an appreciable quantity in the area. The expedition succeeded in marking about a hundred halibut, but recoveries have not been announced so far. Cod also were marked (off Angmagssalik), and several of these have been recaught at Iceland. The catch of cod was most variable, as it must always be in these seas from one place to another, in different seasons and in different periods. Unfortunately there is no information about the size of the cod, the age-composition of the stock and maturity stages, so that a comparison between these valuable data and the corresponding data from Iceland and west Greenland is not possible.

In the hydrographical survey Professor Helland-Hansen gives a series of sections for the periods in which the observations have been made. During the last 10 years so many facts from this area have been gathered (besides Iversen's those from the "Meteor", "Dana", and other vessels), so we hope that it will soon be possible to describe the hydrography of the area fairly fully, a question in which biologists are most interested. At present, such matters as the current conditions, the periodical fluctuations in the strength of the Irminger current, in the temperature, etc. are so far very incompletely known or inaccessible to biological investigators.

The last 70 pages or so of Thor Iversen's work are devoted to Jan Mayen and illustrated with many excellent pictures. This area has been treated in the same way as south-east Greenland, and the great mass of information will be most useful to later expeditions in this distant area. Iversen here deals in more detail than in the first part with conditions in the country, but adds to the description of the fishery experiments (given in detail, pp. 164—171) a number of most valuable facts about the catch of cod and herring in this area, otherwise very poor in fish species. Concerning the cod, which, in the present mild period, has been met with in fairly large numbers off Jan Mayen by Dr. J. Charcot and Thor Iversen himself, Iversen mentions the fact that Icelandic hooks have been found in some of the cod caught in both 1930 and 1931; by marking experiments off Jan Mayen Iversen has also been able to prove that cod from this area migrate to Iceland. Thus, by means of these investigations, we have the valuable information that the cod stock of Jan Mayen must be considered as an outrunner of the Icelandic stock of cod, possibly seasonally determined, and that probably it has no connexion with the Svalbard-Björnö stock. Unfortunately no information is given about the

age composition and maturity stages of the cod. However, by comparing the length curve for 1930 (p. 117) with corresponding curves from Iceland (Tåning 1931) one is able to see that the bulk probably belonged to the very rich year-class 1922, and as the peak of the curve lies a little higher than the curve of the corresponding year-class of immature fish from north Iceland it is very likely that at least a part of the fish spawned earlier in the year off the west and south coasts of Iceland. Presumably it is not possible to carry on a profitable fishery off Jan Mayen.

In comparison with the cod it is interesting to notice that the herring caught at Jan Mayen by Dr. Runnstrøm are ascribed to the Norwegian herring population and not to the Icelandic. This difference in origin of the two species both arriving at Jan Mayen pelagically certainly calls for further investigation.

I ought to call attention to many other observations concerning fish, whales, birds, etc. from Thor Iversen's interesting work, especially as it is written in Norwegian and thus not easily accessible to the numerous investigators who would be glad to have information about these distant areas. I hope that in time, however, the author will gather his many observations from these inhospitable northern seas in a book written in one of the great languages, which if it is as captivating and as beautifully produced as the present, will not lack readers.

A. V. T.

G. Belloc. "Étude monographique du Merlu *(Merlucius merluccius)*. 3e. partie." Rev. Trav. Office des Pêches Marit. T. VIII, Fasc. 2. Paris, 1935.

Cette troisième partie de l'étude du merlu entrepris par M. G. Belloc est consacrée à la moyenne vertébrale, aux essais de marquage du poisson en mer, aux lieux et saisons de pêches depuis la Mer Celtique jusqu'à la côte d'Afrique, et aux migrations.

La moyenne vertébrale trouvée a varié entre 50·48 ± 0·29 pour le merlu capturé au large du Cap Blanc (Maroc) et 51·27 ± 0·24 pour celui provenant de la région à l'Ouest de l'Irlande. L'auteur conclut que "la moyenne vertébrale des merlus varie suivant les régions; elle augmente avec la latitude." Il serait très intéressant d'avoir quelques détails supplémentaires sur le nombre des observations faites, étant donné que le merlu est une espèce qui, par sa valeur marchande très élevée, n'est pas toujours facile à obtenir pour ce genre de recherches. L'auteur lui-même, d'ailleurs, signale que son matériel n'est pas encore suffisamment abondant pour permettre de déterminer avec précision les différences locales.

Les essais de marquage, commencés en août 1931 par l'auteur et un des naturalistes du Laboratoire des pêcheries de Lowestoft, M. C. F. Hickling, à bord du navire de recherches anglais "Georges Bligh", ont révélé de grandes difficultés d'exécution. La technique employée est décrite. Pendant la première croisière les deux naturalistes ont marqué 78 merlus et, plus tard M. C. F. Hickling a put marquer 796 de plus. Une seule recapture est rapportée, d'un merlu marqué le 10 août 1931, longueur totale 28·9 cm., libéré sur les fonds de Ballycotton (Sud-Est de l'Irlande) par 70 m. de profondeur. Il a été repris huit mois et demi après, le 21 avril 1932, par un chalutier français qui pêchait au Nord de la Grande Sole (par 320 m. de prof.). La taille était alors de 40·6 cm., et le lieu de recapture est situé à 130 milles de l'endroit où il avait été remis à la mer. La croissance avait été rapide (11·7 cm. en 8 mois et demi) et la migration s'était faite dans le sens des plus grandes profondeurs de la mer. Ce résultat, unique pour

le moment, mérite bien d'être reproduit ici non seulement en raison des renseignements qu'il fourni déjà mais aussi parcequ'il nous permet d'espérer d'autres succès futurs, plus intéressants encore.

Après une brève description des lieux de pêche déjà indiqués, l'auteur donne le résultat du dépouillement des feuilles de pêche qu'il a obtenu des capitaines de chalutiers français, sous la forme de cartogrammes bi-mensuels (moyennes de 10 ans, 1921 à 1930) et quelques autres graphiques des variations du rendement de la pêche du merlu dans différents lieux, ayant garde à la profondeur travaillée. Les renseignements ainsi réunis et présentés, offrent un intérêt remarquable.

Les migrations du merlu, c'est le titre du chapitre de cet étude de M. B e l l o c. Ici, en raison de la grandeur du problème et de l'insuffisance des données actuelles, le champ des hypothèses est largement ouvert. Notons, tout d'abord, un point de terminologie: M. B e l l o c réserve le nom de "migrations" aux "mouvements saisonniers d'assez grande amplitude" et celui de "déplacements" à "ceux de faible amplitude portant sur une période beaucoup plus courte, par exemple, les changements de niveau au cours d'une même journée." Il ajoute: "les migrations sont naturelles, elles obéissent à un rythme biologique. Les déplacements, qui se superposent aux migrations, sont accidentels." Comme exemple de déplacements, dans ce sens, l'auteur signale celui provoqué, selon lui, par le soulèvement de "denses nuages de vase (par les chaluts trainés sur le fond), créant ainsi un milieu moins respirable pour le poisson." "Ce déplacement en altitude peut être de faible amplitude (quelques mètres, juste un peu plus que la hauteur à laquelle la corde du dos du chalut est entrainée) et donner cependant l'impression qu'il n'y a plus de poissons." Cette hypothèse est étayée: 1) des constatations faites sur le rendement de la pêche d'un chalutier travaillant d'abord sur un certain lieu et, ensuite, après l'arrivée d'un grand nombre d'autres chalutiers qui pêchèrent ensemble; 2) des observations sur le sédiment extrait par le lavage des branchies de merlus capturés dans les deux cas précédents. L'auteur se propose de poursuivre ces recherches qui, en effet, méritent un étude approfondi en raison de son application à la pratique de la pêche.

Des migrations proprement dites, l'article ne s'occupe que de celles des jeunes merlus. Signalons, à ce sujet, les moyennes de la longueur totale des merlus capturés à des profondeurs de plus en plus grandes, au large de la côte française du Golfe de Gascogne (12 cm. par 70—80 m.; 19 cm. par 100—120 m. et 21 cm. par 150—170 m.). Du rôle de la densité (au sens physique du terme) du merlu dans les migrations, hypothèse suggérée par l'auteur sous certaines réserves, très approuvables evidemment, il nous faut attendre des faits plus clairs et démonstratifs; la question est tout simplement amorcée dans ce travail.

L'auteur annonce, pour une quatrième partie, l'exposition de ses recherches sur les migrations du merlu adulte (de *concentration* et de *dispersion*), leurs facteurs déterminants, la reproduction et la nourriture de ce poisson.

A. Ramalho.

H. Blegvad. "Transplantations of Plaice from the North Sea to the Belt Sea, 1928—1933. The Scientific Survey." Rep. Danish Biol. Stat., Vol. XXXIX, 1934, pp. 11—84, 43 Fig. Copenhagen, 1935.

The Fisheries Inspectorate of Denmark acting in collaboration with the scientific staff of the Danish Biological Station have been, since 1928, transplanting about a million plaice a year from the crowded nursery

grounds of the North Sea to the underpopulated Danish waters of the Belt Seas. The work has been financed in the main by the Danish government and it has been an undoubted commercial success. The Danish fishermen have profited to the extent of 168,000 kr. (over £ 8,000) a year, or, taking the cost of transplantations and of the scientific supervision into account, an annual profit of over 200 per cent. is shown. These are the minimum figures, as Dr. B l e g v a d in his admirable report has purposely underestimated the profits.

The great interest of the report lies in the application of scientific methods to a commercial undertaking and also it shows the practicability of extending this profitable fish-farming to other areas.

Each transplantation has been carefully watched. Many thousands of fish have been marked and thousands of age determinations, measurements, etc. have been made both of the transplanted plaice and of the local stocks in the Belt Seas. The estimation of the growth-rates of the two races brings out the interesting fact that the transplanted fish increase in size more rapidly than the local fish. The former growing 12 cm. and the latter 8 cm. in the first year after marking. Dr. B l e g v a d attributes this to the "higher potential growth energy" of North Sea plaice. The carefully analysed growth-rate of each year's transplantation has enabled the observers to find out the most profitable size at which to transplant the fish, which is evidently about 21 cm. Plaice much below this size have less vitality and do not stand the handling and transport so satisfactorily.

Inevitably during the course of the work the supervisors have improved the technique, and it has now reached a high degree of perfection. So much has been learnt that there would seem to be few obstacles to be overcome in extending such undertakings to transplantations to the Dogger Bank where all nations could participate in the benefits. Dr. B l e g v a d points out that even in the Belt Seas there is a need for the protection of the just transplanted fish — this would certainly also be necessary in large scale Dogger Bank transplantations. In the reviewer's opinion this could be done if all nations fishing the North Sea shared in the expense of the work. It would then be to the advantage of everyone to make it a commercial success and all could agree to have a closed season on the Dogger during the time that the fish were put out and for a definite period afterwards. There is always the difficulty of assessing the share to be paid by each nation, but this could be overcome by marking a number of fish at the time of transplantation and proportionating the cost to the number of returns by each nation of the marked fish.

Everyone who is interested in the North Sea plaice stock, both scientific workers and the men who gain their livelihood by fishing, should read this report, since it shows that man can indeed farm the seas and redress the balance of nature which he has done so much to destroy.

D. E. T.-P.

M. Graham. "Investigations of the Herring of Passamaquoddy and Adjacent-Regions." Journ. Biol. Board Canada. Vol. II, No. 2, pp. 95—140, 16 Fig. Toronto, 1936.

This paper is the result of an investigation into the probable effects on the "sardine" herring fishery in the Passamaquoddy and adjacent regions of the building of power dams across the mouth of Passamaquoddy and Cobscook Bays.

An outline is given of the fishery which is carried on mainly by weirs. The notable differences in the yields of closely adjacent weirs are discussed

and are ascribed to the "extremely local conditions." Fishing is carried out throughout practically the whole year but the greatest activity takes place from July to October. During this period there are two main size-groups in the herring population, one with a modal size of 10—11 cm. which the author reckons to be 12 months old, and another group with modal sizes ranging most frequently between 18 and 22 cm. Variation in the modal sizes is attributed to a tendency of the herring to shoal according to size within their group.

The most important spawning ground is reputed to be in the neighbourhood of Grand Manan Island, where spawning takes place in July and August, but the author expresses the view that the spawning grounds in this region and within the Bay of Fundy are not sufficiently extensive to maintain the great shoals of sardine herring which appear off the coasts of New Brunswick and Maine.

Herring fry were found during the winter and early spring months off the south coast of Nova Scotia, where according to current investigations they may be drifted into the Bay of Fundy and ultimately reach the sardine area. From a study of physical conditions the author does not accept Huntsman's theory that the sardine herring are drifted along with their food to the grounds where the fishery takes place, but expresses the opinion that there is migration from numerous different sources, and in fact he supplies evidence which suggests that during the period of the fishery there is a more or less constant migration to and from the places where fishing is carried on. Turbidity is observed as the most characteristic feature of the sardine area and is regarded as a possible factor rendering it specially attractive to herring. It is concluded that the building of the proposed power dams would have little influence on the actual herring stock, but would certainly adversely affect the weirs within and near the enclosed areas.

The paper is well illustrated by means of charts, and relevant tables are given as appendices. One wishes that it had been possible to reproduce some of the charts on a bigger scale. A misprint at the top of page 113 gives measurements in mm., where obviously cm. is intended.

The investigations, which covered a comparatively short period extending from September 1931 to October 1932, achieved their main objective, and although many biological questions relative to the sardine herring have not been explored, this work should prove a useful preliminary to more extensive investigations in this region. *H. W.*

W. F. Thompson. "Conservation of the Pacific Halibut, an International Experiment." Smithsonian Rep. for 1935, pp. 361—382, 2 Plates. Washington, 1936.

In this paper the leader of the great achievement on the Pacific coast gives an excellent and readable summary of the regulation which the International Commission has been able to effect, and the scientific basis for it. Most of the papers in which the work was first described have been reviewed in this Journal, but the present paper deserves reference, both because it is a compact account of the whole work and because it puts so clearly and simply the principle on which all fishing will have to be based in the future. "It may seem to the fisherman somewhat like magic; that by fishing less he can obtain as much or more from the sea than before." Scientists in Europe unfortunately still see more of the corollary: — By fishing more and more, the fishermen obtain as little or less than before. *M. G.*

S. Runnström. "Die Anpassung der Fortpflanzung und Entwicklung mariner Tiere an die Temperaturverhältnisse verschiedener Verbreitungsgebiete." Bergens Museums Årbok 1936, Naturvid. rekke, Nr. 3, pp. 3—36. Bergen, 1936.

Der Verfasser hatte in einer früheren Arbeit den Nachweis erbracht, dass gewisse, im Küstengebiet der nordischen Meere lebende Tiere in ihrer Fortpflanzung und Entwicklung an engere Temperaturgrenzen gebunden sind als in ihrem vegetativen Leben. In der jetzt vorliegenden Arbeit werden eine Reihe mediterraner Arten auf die gleichen Verhältnisse untersucht, nämlich *Ascidia mentula, Ciona intestinalis, Phallusia mammillata, Psammechinus microtuberculatus, Sphaerechinus granularis, Paracentrotus lividus* und *Arbacia aequituberculata.*

Runnström findet, dass man am selben Standort Individuen fangen kann, die durchaus verschiedene Laichbedingungen haben. So beobachtete er in Monaco im gleichen Fang Individuen von *Paracentrotus* mit einem Temperaturbereich von 8—23° und von 8—29°. Bei *Ciona intestinalis* wurden nebeneinander Individuen gefunden, deren Laichbereich 8—23° und 14—27° betrug. Aus diesen und ähnlichen Beobachtungen glaubt der Verfasser schliessen zu dürfen, dass es sich nicht um individuelle Anpassungen an verschiedene Temperaturbedingungen handeln kann, vielmehr lässt sich mit einer gewissen Wahrscheinlichkeit annehmen, dass jede Art in eine Reihe physiologisch verschiedene Rassen zerfällt, die durch Mutation entstanden sein dürften.

Es wird angenommen, dass die genannten Arten ursprünglich an ein gemässigt atlantisches Klima angepasst waren und sich durch die geschilderte Rassenbildung ein weiteres Verbreitungsgebiet erobert haben. Bei *Phallusia* lässt sich eine atlantische (8—23°) und eine mediterran-atlantische (9—27°) Rasse unterscheiden, bei *Arbacia* eine mediterran-atlantische (8—29°) und eine mediterrane Form (14—29°) gegeneinander abgrenzen. Bei *Ciona*, die im Mittelmeer das ganze Jahr hindurch geschlechtsreif ist, und deren Verbreitung bis hoch in den Norden reicht, lassen sich drei ihrer Laichphysiologie nach verschiedene Formen unterscheiden: Eine mediterran-boreale Form (8—23°), eine rein mediterrane (14—27°) und eine boreale Form (6—18°).

Runnström stützt sich bei seinen Angaben, für die er eine experimentell-genetische Analyse nicht beibringen kann, auf verschiedene Befunde bei anderen Tierstämmen, vor allem auf die sorgfältige Analyse, die Goldschmidt 1932 an den Raupen des Schwammspinners *Lymantria* durchgeführt hat. Hier hat es sich experimentell zeigen lassen, dass Anpassungscharaktere an verschiedene klimatische Bedingungen wie Entwicklungsgeschwindigkeit, Dauer der Überwinterung im Ei etc. erblich fixiert sind. Es ist sehr wahrscheinlich, dass es bei marinen Tierstämmen Entsprechendes gibt. Im Hinblick darauf, dass über die Rassenbildung auf physiologischer Grundlage bisher viel zu wenig geforscht worden ist, muss die Runnströmsche Arbeit als äusserst wertvoll auf das wärmste begrüsst werden.

v. Buddenbrock.

R. Spärck. "On the relation between metabolism and temperature in some marine lamellibranches, and its zoogeographical significance." Kgl. Danske Vidensk. Selskab, Biolog. Medd. XIII, 5, pp. 1—27, 16 Fig. København, 1936.

Der Verfasser hat für eine Reihe von marinen Muscheln die Abhängigkeit des Sauerstoffverbrauchs von der Temperatur festgestellt und ist dabei zu

der Aufstellung verschiedener Gesetzlichkeiten gekommen. Zunächst ist festzustellen, dass es eine sehr deutliche Korrelation gibt zwischen dem Sauerstoffverbrauch und der Ökologie der Art. Tiere, die frei auf dem Boden leben, haben einen wesentlich höheren Sauerstoffverbrauch als solche, die sich im Schlamme vergraben. Dass hierbei die Beweglichkeit von Ausschlag ist, zeigt sich daran, dass die Auster, die zwar im freien Wasser lebt, aber festgewachsen ist, einen Sauerstoffverbrauch zeigt, der etwa mit dem der Schlammbewohner übereinstimmt. Auf der anderen Seite sind die sehr beweglichen Pectiniden und Limiden durch einen Sauerstoffverbrauch ausgezeichnet, der in derselben Grössenordnung liegt, wie derjenige gewisser pelagischer Fische, der Krebse und der Austernlarven.

Der Verfasser findet ferner eine sehr bemerkenswerte Abhängigkeit des Sauerstoffverbrauchs von der geographischen Verbreitung, und zwar ergibt sich hierbei, dass die arktischen Arten im Verhältnis zu den Mittelmeerarten einen recht hohen Sauerstoffverbrauch besitzen. Auf diese Dinge hat der Verfasser bereits in früheren Veröffentlichungen aufmerksam gemacht. Es sei dies näher für die Gattung *Pecten* ausgeführt. Der arktische *Pecten groenlandicus*, der bei einer Wassertemperatur von wenig über 0° lebt, verbraucht bei + 1° 25 c.c. p. kg. u. St., schon bei wenigen Grad über 0° steigt der Verbrauch auf 50—60 c.c. Der boreal-mediterrane *Pecten varius* verbraucht dagegen bei 5° nur 25 c.c. Der mediterrane *Pecten flexuosus* begnügt sich bei der gleichen Temperatur mit einem Sauerstoffverbrauch von nur 10 c.c.

Ähnliches lässt sich für viele andere Arten beweisen. So hat der dänische *Mytilus edulis* einen deutlich höheren Stoffwechsel als die Mittelmeerrassen der gleichen Art, die grönländischen *Astarte*-Arten haben einen höheren Sauerstoffverbrauch als die aus den dänischen Gewässern.

Wie der Verfasser hervorhebt, scheint es sich hier um eine geographische Rassenbildung zu handeln im Sinne von Runnström. Es ist offenbar so, dass Tiere, deren Stoffwechsel durch niedere Temperaturen sehr herabgedrückt werden würde, in den arktischen Gewässern nicht gedeihen, wachsen und sich fortpflanzen könnten, wenn sie nicht einen sehr energischen Stoffwechsel hätten. Auf der anderen Seite ergibt es sich, dass die arktischen Arten bei höheren Temperaturen zugrunde gehen, *Pecten groenlandicus* z. B. bereits bei einer Temperatur von 8—10°. Der Verfasser betont daher, dass die sogenannten stenothermischen Tiere als solche betrachtet werden müssen, die einen arktischen Stoffwechsel haben.

Erwähnt sei, dass derartige Abhängigkeiten seit längerer Zeit auch für das Blut der marinen Fische bekannt sind, das bei arktischen Tieren ganz andere Eigenschaften besitzt als bei südlichen. Die Arbeit von Spärck ist daher eine wichtige Bestätigung und Erweiterung dieser älteren Befunde und ein wertvoller Beitrag zur Kenntnis des Stoffwechsels mariner Tiere.

v. Buddenbrock.

H. Thamdrup. "Beiträge zur Ökologie der Wattenfauna auf experimenteller Grundlage." Medd. Komm. Danmarks Fisk.- og Havunders. Ser. Fisk. Bd. X, Nr. 2. København, 1935.

This paper deals principally with an investigation carried out on the intertidal fauna inhabiting a typical area on the east coast of the Skalling peninsula, which lies to the south-east of Blaavands Huk. Supplementary investigations were made on other parts of the North Sea coasts. The paper is much more than a mere account of the local fauna. While the distribution of the local species is naturally fully dealt with, the reactions and relationships of the different animals to their environment have been

investigated in varying detail, and a considerable amount of correlated experimental work undertaken. The paper is the best account which we have at present of a piece of shore ecology in all its aspects, as may be gathered from the titles of the principal sections into which the paper is divided: — physical-chemical factors; general biology of the dominant species; distribution of the various year-groups; rate of growth of *Macoma* and *Cardium;* distribution of the various species on the shore, etc. There is, in addition, a very full bibliography of papers dealing with the subject, to which constant reference is made. There are also twenty-six clear and interesting plates at the end of the paper which give a very good idea of the type of ground on which the work was done, and of the detailed appearance of the habitats of the principal species.

With regard to the physical-chemical factors some ten were analysed, and of these, period of submergence, texture and water-content of the substratum, temperature and food-supply were found to be the determining factors.

The investigations at Skalling were carried out along two lines on the shore, each about five hundred metres in length, extending from H. W. M. to L. W. M. The fauna was that usually associated with the *Cardium-Macoma* zone divisible into two sub-zones, an upper one marked by *Hydrobia-Pygospio-Corophium,* and a lower one marked by *Arenicola-Cardium-Macoma.* In parts the population was very dense, although the number of species is naturally rather limited. As many as 3,000 to 4,000 individuals, having a weight of 3·4 kg., were taken on a square metre.

A series of curves is given showing the numbers of each species per m.^{2} and their weight, at different seasons. These give a clear idea of the seasonal variations in density and distribution.

Arenicola was found most abundantly where the sand was mixed with a little mud; *Scoloplos* where there was pure sand. *Corophium* cannot live on the same ground as *Cardium,* since the latter breaks up its tubes. *Macoma* was found to be most abundant in the lower reaches of the beach, since it is there that its food is most abundant.

At the higher stations the numbers of individuals were much greater than at the lower stations (as 16 : 1), but the total weight was in the reverse order (as 1 : 30). The consumption of oxygen was also greater at the lower stations (as 1 : 7).

Altogether this is a most interesting and useful paper and the author is to be congratulated on it. We look forward to further contributions on the same subject, more especially on certain important problems which have just been touched on in the present paper, and on which further work is promised.

A. C. S.

E. Fischer-Piette. "Études sur la biogéographie intercotidale des deux rives de la Manche." Journ. Linn. Soc. London, Zool., Vol. XL, pp. 181—272. London, 1936.

For a number of years Dr. Fischer-Piette has studied the distribution of the common species of animals and algae in the littoral zone on the two sides of the Channel, and he has now brought together the results of his investigations in the form of charts of the variation of abundance of the different species from place to place. While emphasizing the necessity of more prolonged study of each individual locality before a positive statement can be made of the absence from it of any given species, he

shows that there are a number of species whose distribution shows a general relation to certain geographical or physical features.

In the first place there are a number of species such as *Laurencia pinnatifida, Purpura lapillus, Littorina rudis* and *Patella vulgata,* which are practically universally distributed. Then there is a second group including the various lichens, and *Patella depressa, P. intermedia,* and *Balanus perforatus* which are influenced chiefly by whether there is a suitable surface for attachment. A number of species show an apparently erratic distribution, but one which is presumably linked with some at present unknown environmental factor, and two of these, *Patella intermedia* and *Actinia equina,* show a marked inverse correlation with one another, the one being rare where the other is common. Two species of barnacles also show an inverse relation of another type, *Balanus balanoides* progressively replacing *Chthamalus stellatus* eastwards up the Channel.

Finally there is a group of species, nearly all algal, whose abundance is greatest on points of land jutting out into deep water, and a second group, all animal, whose numbers increase markedly in the more sheltered bays. Among the former are *Bifurcaria, Alaria* and *Himanthalea,* and among the latter *Pomatoceros, Mytilus edulis* and *Balanus perforatus.*

A sufficient number of localities has been worked for the above facts of distribution to be taken as significant, and the next step is to correlate them with definite environmental factors. Unfortunately this is difficult, and Dr. Fischer-Piette, who has made a big step forward in thus indicating where such factors are to be sought, is able to make only a very tentative suggestion of a substance beneficial to certain species in the inshore waters of bays, and of a factor beneficial to others in the pure waters round exposed headlands. Admittedly such factors appear to exist, but it is hard to reconcile the apparent sensitivity of an alga such as *Himanthalea lorea,* which is supposed to be favoured by the comparative purity of the water in the Lizard—Start Point area, but excluded by the less pure waters of the Start Point—Portland Bill area, with its abundance in the relatively very muddy waters of Plymouth Sound. Such difficulties are freely admitted by Dr. Fischer-Piette himself, and it is to be hoped that his further work will be able to provide an answer to them.

H. B. M.

H. B. Moore. "The Biology of *Balanus balanoides.*" Journ. Mar. Biol. Assoc. N. S., Vol. XIX—XX, Plymouth, 1934—1936.

I. "Growth Rate and its relation to Size, Season and Tidal Level." (Vol. XIX, No. 2, 1934.)

The locality chosen for the investigation is situated in the Dub Reef in Port Erin Bay, and about a hundred specimens of *Balanus* at three different levels of the rocky shore were kept under observation for a whole year. As soon as the new spat were large enough for measurements a series of these was also included. A method of measurement was employed which allowed a calculation of the volume of the barnacle.

It was found that the growth-rate is greatest in the smallest individuals and in those at the highest level. As regards the seasonal variation there was in general a high growth-rate for a short period in the spring and summer, followed by a period of slower growth throughout the winter. The time of maximum growth-rate varies, however, on the different patches and with different sizes of barnacles.

It seems that a group of the young barnacles settled later than the typical members of the community and this group was not able to get

through their early period of rapid growth before the retarding effect of the summer heat set in. The later settled spat made, however, good progress by the beginning of the following year and the wide difference of size found in first-year barnacles is therefore not maintained in the second year.

The barnacles from the lower zone have a much smaller growth-rate throughout the whole of their life than the members of the middle and top zone. Most of the lower- and middle-zone barnacles usually spawn only once and die in their third year, but those from the extreme top zone may live for five years or more and spawn many times in their life. The members of the upper zone, although less numerous, therefore produce a large amount of spawn.

III. "The Soft Parts" (Vol. XX, No. 2, 1935.)

The present paper comprises an account of the changes in the soft parts of the barnacle and the variations with age, season, and tidal level. The normal growth of the shell and the corresponding growth of the soft parts in terms of dry weight of decalcified tissues is demonstrated graphically. The cycle of changes in the weight of body is, in immature animals, characterized by a continuous growth throughout the year, which is most rapid during the spring and autumn. In mature barnacles which produce a considerable amount of larvae, there is a slight drop in weight in winter and also a considerable loss of weight during the following summer period. The author suggests that the maturation of the larvae in the mantle cavity during the winter involves some expenditure of energy and corresponding loss of weight on the part of the barnacle. As soon as the larvae have been liberated into the sea, the body-weight rises steadily to its June maximum.

The shedding of the ova and impregnation takes place in November and the nauplii are liberated into the sea from February onwards, with a maximum in March. At the lowest level on the shore the barnacles mature in their first year, but at higher levels they do not commence to mature until over a year old. In the extreme upper limit of the barnacle zone some individuals were recorded as senile which possibly may be due to some form of parasitic castration.

The naupliar content is estimated in relation to size and tidal level, and the larval output of average individuals of successive year-groups at different levels of the shore is demonstrated.

The average dry weight of one nauplius was estimated as $7{\cdot}5 \times 10^{-4}$/mg.

IV. "Relation to Environmental Factors" (Vol. XX, No. 2, 1935).

One of the chief environmental factors, after tidal level, is the degree of exposure to wave-action and the author has made an attempt to give a numerical value to this factor. Four localities in the Isle of Man with different coefficients for the exposure factor were investigated.

The upper limit of vertical distribution of barnacles at the most sheltered locality is almost exactly at high water of mean neap-tides. With increasing exposure to wave-action, the upper limit rises, until outside Bradda it is almost at high water of extreme spring-tides. The lower limit of distribution drops similarly with increasing wave-exposure from just below mean sea-level to halfway between mean low-water neaps and mean low-water springs.

The wave action has an advantageous effect on the growth. As regards the first-year barnacles the largest individuals are those which live at low water. This generalization holds good for all degrees of wave exposure, but the general rate of growth is greatest in the most exposed situations. In very exposed localities the same conditions of greatest rate at low water hold good for the second- and third-year barnacles also, but at all more sheltered stations the optimum level for growth moves steadily up the shore with advancing age. The author supposes that there is a harmful factor

present in the water in more sheltered situations which tends to retard the growth of the older barnacles, but not the spat, and perhaps thereby raises the lowest limit at which they can survive.

Increased exposure to wave action has also the effect of accelerating the onset of sexual maturity and this always occurs earlier at low levels on the shore than it does higher up. The author discusses the effect of temperature, salinity, oxygen concentration, crowding, etc.

He has also made some interesting observations on the effect of current on the orientation of barnacles. Observations from a suitable locality sheltered from wave action and subject to a steady tidal current indicate the change from the alignment of most of the spat along the current to the adult condition with most of the barnacles lying across the current. It seems likely that a rotation takes place. An orientation across the current is the best position for continuous feeding in a current which reverses its direction periodically.

Finally the author has estimated the total barnacle population on the shore. At the most exposed locality it is calculated at about a thousand million individuals per kilometre of shore with a yearly output of about 600 kg. dry weight of tissue in addition to a million million larvae, weighing 90 kg.

V. "Distribution in the Plymouth area" (Vol. XX, No. 3, 1936.)

The Plymouth area offers very different conditions from those localities in the Isle of Man previously investigated. The rivers which discharge into Plymouth Sound carry with them a large quantity of suspended matter and give a somewhat lowered salinity. The area lies also in an intermediate position between the region where *Chthamalus stellatus* predominates and that where *B. balanoides* does.

The distribution of the two species is studied in relation to tidal level in five localities and a comparison is made with the observations made in the Isle of Man.

The conditions at the two "clean water" localities are quite comparable with those observed in the Isle of Man and similar distributions of barnacles were found. At the other three localities with a great quantity of suspended matter the reducing effect of some environmental factors on the numbers of *Balanus* present is to a large extent outweighed by an increased growth-rate due to the rich food material present. Since the same effect of increased growth-rate was observed in wave-exposed conditions in the Isle of Man this would seem to support the suggestion made by the author previously that the beneficial effect of water movement was due to the greater quantity of food material which it brought within the barnacle's reach.

Sven Runnstrøm.

M. W. Parke and H. B. Moore. "The Biology of *Balanus balanoides*." II "Algal Infection of the shell." Journ. Mar. Biol. Assoc. N. S., Vol. XX, No. 1. Plymouth, 1935.

The authors describe a method of differentiating the successive year-groups by the colour of their shells caused by algal infection. The typical colour-changes are demonstrated in a diagram. The new shell formed in the summer gradually becomes coloured by the following spring. By early summer the old shell-growth is sharply marked off from the new growth of white shell now making its appearance. The same sequence of colour-changes is followed in the second and third seasons by the newly formed shells of those years, while the old shell of previous years continues to darken. The series of changes was verified on animals of known age.

A list of all the species of algae found by the authors is given together with notes on their distribution and reproduction. The colonization of the shell is described. With two exceptions there seems to be no correlation between the distribution of any of the species found and tidal level. There is, however, a marked correlation between the abundance of some of the species and the degree of wave exposure of the locality.

It may be assumed that in addition to the protection afforded by the shell, the alga also benefits from the excretory products of the barnacles. The alga will in return benefit the barnacle by removing its waste products from the water.

Sven Runnstrøm.

C. L. Newcombe. "Growth of *Mya arenaria* L. in the Bay of Fundy Region." Canadian Journ. Res. Ser. D, Vol. 13, pp. 97—137, 8 fig. Ottawa, 1935.

In dieser sorgfältigen Arbeit wird ausführlich nachgewiesen, dass die konzentrischen Ringe auf der *Mya*-Schale Jahresringe sind. Mit Sicherheit ist das Alter der 1—8 Jahre alten Klaffmuscheln zu bestimmen, während es bei den älteren Muscheln schwierig ist, die dicht nebeneinander liegenden äusseren Ringe zu zählen. Das Wachstum des ersten Sommers und Herbstes ist bei den älteren *Mya* nicht mehr zu erkennen und ist auch sehr verschieden, aber vom 2. Zuwachsring an wurden meist übereinstimmende Zuwachswerte gefunden. Der jährliche prozentuale Schalenzuwachs nimmt regelmässig mit dem Alter der *Mya* ab. Genaue Messungen an Klaffmuscheln, welche an verschiedenen Plätzen der Gezeitenzone in Versuchskasten gehalten wurden, gaben einen guten Einblick in das jahreszeitliche Wachstum: der grösste Zuwachs erfolgt im Sommer, an 2. Stelle steht der Zuwachs im Frühjahr, dann der im Herbst. Im Spätherbst findet nur in besonders günstigen Jahren noch ein Wachstum statt, im allgemeinen ruht das Wachstum von Oktober bis März. Durch geeignete Versuchsanordnung und Beobachtung der Bodenbeschaffenheit, Temperatur und des Salzgehaltes wurden Faktoren gefunden, welche im Verband mit allen Faktoren des Lebensraumes einen hemmenden Einfluss auf das Wachstum ausüben. Besonders wird dabei auch die Nahrung der *Mya* behandelt nach Magenuntersuchungen und Planktonfängen. Die wichtigste Nahrung bilden aufgewirbelte Bodendiatomeen, während Detritus nicht in Frage kommt. Die massenhaft gefundenen Tintinnen sind wahrscheinlich als leere Gehäuse eingestrudelt. Die Diatomeenwucherungen machen sich beim Wachstum der *Mya* bemerkbar; es wird festgestellt, dass die Nahrungszufuhr gegenüber der Temperatur den grösseren Einfluss auf das Wachstum hat.

Wenn es sich auch nur um die Schalenmessungen handelt — die Gewichtsbestimmungen sollen noch folgen —, so gibt uns diese sorgfältige Arbeit doch einen sehr guten Eindruck von der Ökologie der *Mya* in der Bay of Fundy und es ist nur zu wünschen, dass die Kollegen an anderen Plätzen ähnliche Arbeiten ausführen.

A. Hagmeier.

C. L. Newcombe. "A Study of the Community Relationships of the Sea Mussel, *Mytilus edulis* L." Ecology, Vol. XVI, No. 2, pp. 234—243. New York, 1935.

Eine gedrängte Übersicht über die Ergebnisse quantitativer Untersuchungen der "*Balanus-Mytilus edulis* Association", wie der Verf. die *Mytilus*-Epibiose nennt. Bemerkenswert sind die Mitteilungen über die zeitliche

Entwicklung der Miesmuschelbank, auf der sich erst allmählich die verschiedenen Epizoën und Epiphyten ansiedeln können, und bei der sich schliesslich auch der Boden verändert, sodass die Endofauna (*Mya* und *Nereis virens*) gestört wird. (Anm. d. Ref. Als "Succession" würde ich diese Folge der Erscheinungen innerhalb derselben Gemeinschaft nicht bezeichnen.) Die einzelnen Arten werden nach ihrer Bedeutung für die Epibiose aufgezählt. Die Tätigkeit der räuberischen Seesterne begrenzt die Muschelbank nach unten. Dass die Miesmuschel unter der NW.-Linie gut gedeiht, ja besser wächst, als in der Gezeitenzone, wird mit Versuchskasten bewiesen, in denen die Muscheln gegen die räuberischen Tiere geschützt wurden. (Anm. d. Ref. *Buccinum undatum* kann nach den bisherigen Erfahrungen keine Muscheln anbohren!) Das grösste Schalenwachstum fand im Frühjahr und Sommer, ein geringeres im Herbst statt. Durch die schönen Beobachtungen und ökologischen Schlussfolgerungen ist die Arbeit für ähnliche Untersuchungen sehr anregend.

A. Hagmeier.

R. Kändler. "Austernwirtschaft im Ausland und in Deutschland." Der Fischmarkt. Nr. 11, S. 284—288; Nr. 12, S. 312—321, 1935; Nr. 1, S. 4—8, 1936. Cuxhaven.

The author's "Die Kultur der Auster," which dealt with the principal methods of oyster culture used in various parts of the world, was reviewed in the Journal some six years ago. Apart from a brief statistical reference to the oyster industry in the U. S. A., the present articles are concerned only with the oyster in northern Europe, particularly in relation to the possibility of reviving the fishery on the coast of Germany near the Island of Sylt, which some sixty years ago was in a reasonably flourishing condition. The figures included in this brief survey give a useful picture of the present state of the European oyster fisheries. Reasons for the complete exhaustion of the Sylt beds are discussed, together with objections to certain measures for re-establishing the beds. Thus with imported Dutch oysters there would be introduced the "thorn" disease and the slipper limpet *(Crepidula)*, while from previous experience it is probable that Brittany oysters would fail to withstand the colder conditions which prevail in the beds in question; nor would the introduction of the Portuguese or American species offer any prospect of reviving the fishery. All that can feasibly be done with any prospect of ultimate success is to concentrate the surviving local oysters in the most suitable places to ensure production of as many as possible healthy larvae. There remains the hope that recent progress in experiments at Heligoland in raising young oysters in the laboratory may, before long, lead to a method for producing an adequate supply of seed oysters to maintain the beds.

H. P. S.

T. Gaarder og P. Bjerkan. "Østers og Østerskultur i Norge." pp. 96, 48 Fig. A. S. John Grieg, Bergen, 1934.

This book is written as a guide to a rational oyster-culture in the Norwegian "poller", those more or less enclosed parts of the fjords in which a very good fall of spat can be obtained, and in which the spat can also be reared to large oysters. A description is given of the anatomy, physiology, development, and chemical composition of the oyster. A special chapter is devoted to the dangers the oyster has to meet, and it is characteristic of the ideas of the authors that starvation is the first factor mentioned: large parts

both of larvae and adults can die by starvation. In a good basin, however, the yearly mortality is only 10—15 %. This is very low, as in Denmark (Limfjord) the mortality is 15—20 %, and in Holland 25 %. That the great mortality in Holland of 40 % in 1930 was caused by bad food conditions has not, as far as I know, been proved. Since the natural oyster banks, that till then had always lain off the Norwegian coast, were totally depleted in 1870—1880 in Norway, just as in the more southern countries, oyster culture has been tried. These efforts have succeeded very well in the "poller". Here a culture has developed that is quite different from that in western Europe owing to the peculiar hydrographical conditions. The "poller" may have a very narrow communication with the fjord; in this case they are used for obtaining spat, while for the growing and fattening of the large oysters a wide canal to the fjord is necessary. In both, however, there is a barrier in the canal. The spat "poller" have in general a depth of 5—10 m. and a surface of 200 × 200 m.; they are protected from the rough winds and a rivulet must give some fresh water. This spreads out over the whole surface and retains the warmth of the underlying salt water, acting as the glass in a hot-house; the particles that give the water an opaque appearance absorb the sunrays. In such a "poll" the temperature in summer is generally above 20°, sometimes even above 30°. The highest temperatures occur at a depth of 2—5 m. These temperatures are too high for fattening, which is done in the "poller" opening widely on the fjord, where temperatures are under 20°. As the salt water under the freshwater layer is not in communication with the atmosphere, the whole amount of the oxygen must be produced by the assimilation of the plants. Near and on the bottom, however, H_2S is produced, and in dark weather in summer, when the O_2 production is low, H_2S can penetrate into the highest layers where the oysters are. This can also occur in autumn, when the temperature is still fairly high and the intensity of the light is decreasing. In all 8 "poller" are in use for spat collecting. In 1933 2·1 million spat were produced. In order to profit from the high temperatures and to avoid H_2S, the whole culture is carried on a few metres above the bottom, and therefore both the oysters for the production of larvae and for fattening and also the collectors for the spat are hanging a few metres below the surface. The growth of both the spat and the larger oysters is very good, but the shells are thinner than with oysters that grow on the bottom.

The book is concluded with a description of methods for taking water samples and for determining temperature, specific gravity, and presence of H_2S (by smell) and of the gear in use.

B. Havinga.

A. Dannevig. "Hummer og Hummerkultur." Fiskeridirek. Skr., Ser. Havunders. (Rep. Norwegian Fish. and Mar. Invest.). Vol. IV, No. 12, pp. 1—60, 16 Fig. Bergen, 1936.

This paper is the result of 20 years of work on the natural history and the artificial rearing of the lobster. It is a summary of the numerous, more detailed articles by the same author. A description is given of the history of the lobster fishery and trade. As long ago as 1737 a close time, during the period of shell moulting, was proposed, but this was not introduced until 1849. In 1879 a minimum size-limit of 21 cm. was added. As to the life history, the geographic distribution, the propagation, development of the larvae, the food and the moult are discussed. The growth was investigated with lobsters marked by means of holes punched out in the tail fin. These marks, that can be applied to different parts of the fin, are

still visible after the first or even the second moult. A length of 21 cm. is attained at about 7 years of age. In the same way it was found that the lobster is very stationary, the migration generally not exceeding 100 metres. About 44 % of the lobsters of about 19 cm. and more are caught each year; from the total catch (2·4 million in 1933) it can be estimated that there must be on the Norwegian fishing grounds about 2·4 × 2·27 million lobsters of this size. A large majority does not attain sexual maturity owing to the low size-limit and the great intensity of fishing. Perhaps a considerable reserve is present on the grounds where there is no fishing.

In the chapter "Hummerkultur" the desirability of a higher size-limit (22 cm.) is discussed, and also a description is given of the rearing apparatus and the results obtained with it. About 20—40 % of the planktonic larvae can be reared to the bottom stage. With this percentage the technical side of the rearing is considered to be solved. The rearing expenses for each young one in the bottom stage are now 5 øre; it is hoped, however, that these can still be reduced considerably.

B. Havinga.

W. C. Smith. "Growth of the Young Lobster *(Homarus vulgaris)*." Proc. & Trans. Liverpool Biol. Soc. Vol. XLVIII, pp. 51—60. Liverpool, 1935.

W. C. Smith has continued his extremely useful experimental study of the early growth of the European lobster. In a previous paper he followed the growth during the first eleven months, at the end of which time he had 72, in May 1933. These fell to 26 by December 1933, and to 2 by January 1935, so the observations extend over 2½ years. He finds in the first growth-period, i.e., June-December of the year of hatching, 7 moults, 3 in the next year (second growth-period) 2 or 3 in the third period and 2 in the fourth. Moulting occurs only when the temperature is 10° C. or higher, i.e., roughly between May and October. He finds, too, that both growth and mortality at moult are definitely highest during the warmest period.

An interesting attempt was made to determine whether young lobsters would continue to moult in winter if the temperature was kept above 10° C. Four out of ten used in this experiment moulted and the remaining six died, which suggests that extended higher temperature may promote growth, but also impair vitality.

R. E.

W. C. Smith and T. N. Cregeen. "An experiment in lobster rearing." Proc. & Trans. Liverpool Biol. Soc. Vol. XLVIII, pp. 61—64. Liverpool, 1935.

In the course of experience in rearing young lobsters Messrs. Smith and Cregeen have found that by keeping 10 larvae in jars of 2,700 c.c capacity about 21 % can be reared to the lobsterling stage. In 1934 they found that by keeping separate individuals in jars of smaller capacity a much higher percentage was reared successfully. One-pound and half-pound jars were found the most useful, showing that vessels of about 160 c.c. capacity, kept well shaded, can be expected to rear over 50 % to the lobsterling stage.

R. E.

Wilhelm Wunder. "Physiologie der Süsswasserfische Mitteleuropas." Sonderabdruck aus dem Handb. d. Binnenfischerei Mitteleuropas, Bd. II B, S. 327, Abb. 213, Taf. 10. Stuttgart, 1936.

Das umfangreiche Werk Wunders bringt eine zuverlässige Übersicht über die Physiologie der Süsswasserfische. Es zerfällt in 9 grosse Kapitel, welche die Physiologie der Haut, der Sinnesorgane, des Nervensystems, der Atmung, des Blutes, der Ernährung, der Exkretion und inneren Sekretion, der Bewegung, sowie der Fortpflanzung und Entwicklung zum Inhalt haben. Jedem Kapitel ist ein ausführliches Literaturverzeichnis beigefügt. Der Verfasser der selbst auf verschiedenen Gebieten der Fischphysiologie als selbständiger Forscher hervorgetreten ist, hat sich grosse Mühe gegeben, die gesamte vorhandene Literatur zu berücksichtigen. Die Meeresfische sind absichtlich ausgelassen worden. Diese bewusste Beschränkung braucht aber nicht den Gedanken aufkommen zu lassen, dass das Buch für die Meeresforschung wertlos sei, da das allermeiste, was von den Süsswasserfischen gesagt wird, naturgemäss auch für die Seefiche gilt. Das Buch wird vielmehr jedem Meeresforscher, der sich mit der Biologie der Fische beschäftigen will, ein unentbehrlicher Ratgeber sein. Abweichendes wird sich vielleicht nur in den Kapiteln Blut, Atmung und Exkretion bemerken lassen. Das Buch ist hervorragend klar geschrieben, das vorgetragene Material kritisch durchgearbeitet. Es ist zu hoffen, dass es die Anregung geben wird, sich auch mit der Physiologie der Meeresfische, die bisher sehr vernachlässigt worden ist, eingehender zu beschäftigen.

W. v. Buddenbrock.

L. Lozano Rey. "Los Peces Fluviales de España." Mem. de la Acad. de Ciências Exactas, Físicas y Naturales de Madrid, Ser. Cien. Nat., Tomo V. Madrid, 1935.

Cet illustre ichtyologiste espagnol, à qui on doit déjà, entre autres publications remarquables, le premier volume de la "Fauna Ibérica-Peces" (Cf. ce Journal, V, 2, 1930, p. 262), en poursuivant sa tâche méritoire a préparé ce nouveau livre consacré aux poissons fluviatiles de l'Espagne. L'Académie des Sciences de Madrid a décerné un prix à l'auteur et a publié l'ouvrage. Cette monographie est comparable, par le plan adopté, la méthode d'exposition et la présentation graphique, abondance en dessins et planches très bien réussies, à celle citée ci-dessus (p. 222), mais, beaucoup de "notes complémentaires" sur les questions de biologie de chaque genre ou espèce traitée, sur la biogéographie et d'autres aspects plus ou moins connexes, formant même le sujet de chapitres spéciaux en quelques cas, donne à l'ouvrage une plus grande valeur. La liste bibliographique, bien que l'auteur ne l'aie pas fait intentionnellement complète, est pourtant assez riche et les indices bien organisés. Les espèces ayant une valeur économique ou autre sont l'objet de renseignements plus spéciaux. C'est, en somme, un ouvrage d'ensemble, comprenant toutefois le résultat d'un grand nombre de recherches personnelles de l'auteur, qui sera consulté fructueusement par ceux qui voudront étudier la faune des eaux intérieures de la Péninsule Ibérique, soit comme sujet autonome soit en vue de la comparaison ou la corrélation avec celles des régions voisines, tant européennes qu'africaines.

A. Ramalho.

Current Bibliography.

Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. Allen's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

Physical and Biological Conditions in the Sea.

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Editorial Notice: the Current Bibliography.

FOR the future, from the first number of Volume XIII of the Journal, it is intended to use a fresh classification for the references published in the Current Bibliography. The difficulty found in placing certain entries under suitable headings made it clear that some revision was necessary. There are to be twelve primary headings (printed in large, heavy type), and the entries will be made under the secondary headings (smaller, heavy type). Entries may be sometimes repeated, but it is to be remembered that the bibliography has a mainly specialist purpose, and is not designed for use as a general work of reference. For this reason a paper on, for example, the Physiology of the Cod would be referred to under 8b (Marine Fishery Investigations, Cod), but not under 6b (Fish, Physiology and Behaviour). Under the latter heading would appear references to papers dealing with the physiology or behaviour of fish in general, or of a fish having no commercial value, and not specifically mentioned under Marine Fishery Investigations.

To facilitate cutting up, the type is to be leaded between each entry.

The Editor would be glad to receive (as early as possible) criticisms and suggestions regarding this classification.

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1) General Oceanography.

- **1) a Expeditions.**
- **1) b Institutes.**

2) Hydrography.

- **2) a Apparatus and Methods.**
- **2) b Surveys.**
- **2) c Chemistry of Sea Water.**
- **2) d Physical Chemistry.**
- **2) e Physical Properties: General.**
- **2) f Temperature.**
- **2) g Submarine Illumination.**
- **2) h Hydrodynamics.**
- **2) i Currents and Oceanic Circulation.**
- **2) j Tides and Sea Level.**
- **2) k Geography and Geology.**
- **2) l Ice.**
- **2) m Meteorology.**

3) Plankton.

- **3) a Apparatus and Methods.**
- **3) b General.**
- **3) c Phytoplankton.**
- **3) d Zooplankton.**
- **3) e Physiology and Behaviour.**

4) Organic Production.

- **4) a General.**
- **4) b Bacteria.**

5) Bottom Fauna and Flora.

5) a Apparatus and Methods.
5) b Systematics and Development.
5) c Distribution and Ecology.
5) d Physiology and Behaviour.
5) e Marine Plants.

6) Fish.

6) a Systematics, Morphology and Development.
6) b Physiology and Behaviour.
6) c Parasites and Diseases.

7) Marine Fisheries.

7) a Commercial Fisheries: Statistical.
7) b Fish Preservation.
7) c Fishing Vessels and Gear.
7) d Fishing Grounds.

8) Marine Fishery Investigations.

8) a Stocks and Effects of Fishing.
8) b Cod.
8) c Haddock.
8) d Hake.
8) e Other Gadoids.
8) f Plaice.
8) g Sole.
8) h Halibut.
8) i Other Pleuronectidae.
8) j Herring.
8) k Sardine.
8) l Other Clupeoids.
8) m Tunny and Mackerel.
8) n Other Commercial Species.
8) o Hatcheries and Aquaria.
8) p Whales and Seals.

9) Freshwater Fisheries and Fishery Investigations.

9) a Salmonidae.
9) b Eels.
9) c Other Commercial Species.
9) d Effects of Pollution.
9) e Ecology.

10) Shellfisheries.

10) a Molluscs.
10) b Crustacea.

11) Mathematical and Statistical Methods.

11) a General.
11) b Hydrographical.
11) c Biological.

12) Miscellaneous.

12) a Hydrographical.
12) b Biological.
12) c Miscellaneous Apparatus.
12) d Unclassified above.

Recent Publications of the International Council:

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Vol. 102: *Foreign Guests in the Baltic and Transition Areas. Scientific Report of the Baltic and Transition Area Committees.* Mai 1937. Kr. 6.00.

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Vol. 105: *Part I: Procès-Verbaux (Juillet — 1937).*
Part II: Rapport Administratif (1936—1937).
Part III: Appendices.
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BULLETIN HYDROGRAPHIQUE *pour l'année 1936.* In preparation.

BULLETIN STATISTIQUE *pour l'année 1935.* In preparation.

Attention is drawn to the Series E:—

FAUNE ICHTHYOLOGIQUE DE L'ATLANTIQUE NORD, of which Nos 1—17 have been issued. No. 18 is in preparation. Each, Kr. 4.00.

Table of Contents.

Page

1. **Sven Runnstrøm.** A Review of the Norwegian Herring Investigations in Recent Years ... 123
2. **A. C. Gardiner.** Phosphate Production by Planktonic Animals ... 144
3. **E. Steemann Nielsen.** On the Relation between the Quantities of Phytoplankton and Zooplankton in the Sea ... 147
4. **S. G. Gibbons** and **J. H. Fraser.** The Centrifugal Pump and Suction Hose as a Method of Collecting Plankton Samples ... 155
5. **Richard Van Cleve.** An Electrical Plankton-Net Closing Device ... 171
6. **Richard Van Cleve.** A Fifteen-Gallon Water Bottle ... 174
7. **R. S. Wimpenny.** A New Form of Hensen Net Bucket ... 178
8. **Wilh. Mannsfeld.** Über die Scholle *(Pleuronectes platessa)* an der lettländischen Ostseeküste ... 182
9. **Alf Dannevig** and **Gunnar Dannevig.** The Season in which "Winter" Zones in the Scales of Trout from Southern Norway are formed ... 192
10. Reviews ... 199
11. Current Bibliography prepared by the Editor with the Assistance of Miss **Thursby-Pelham** ... 237
12. Editorial Notice: the Current Bibliography ... 254

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